The Electrochemical Society . . .

110th Meeting

CLEVELAND

Sept. 30—Oct. 4, 1956

LOCAL COMMITTEE

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Mrs. M. Korver

Cleveland Program

THE ELECTROCHEMICAL SOCIETY

One Hundred and Tenth Meeting

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Sunday through Thursday

September 30, October 1, 2, 3, and 4, 1956

CONDENSED TECHNICAL PROGRAM

Battery (Abstracts 1–20)

(All sessions in Pine Room)

Monday morning, Oct. 1—9:30 A.M.–12.00 M.

Monday afternoon, Oct. 1—3:00 P.M.–5:00 P.M.

Tuesday morning, Oct. 2—9:00 A.M.–12:00 M.

Tuesday afternoon, Oct. 2—2:00 P.M.–4:30 P.M.

Battery-Theoretical Electrochemistry (Abstracts 21–30)

(Both sessions in Pine Room)

Wednesday morning Oct. 3—9:00 A.M.–11:30 A.M.

Wednesday afternoon, Oct. 3—2:00 P.M.–4:30 P.M.

Corrosion (Abstracts 31–61)

(All sessions in Ohio Room)

Tuesday morning, Oct. 2—9:00 A.M.–11:45 A.M.

Tuesday afternoon, Oct. 2—2:00 P.M.–5:15 P.M.

Wednesday morning, Oct. 3—9:00 A.M.–11:45 A.M.

Wednesday afternoon, Oct. 3—2:00 P.M.–5:00 P.M.

Thursday morning, Oct. 4—9:00 A.M.–11:45 A.M.

Thursday afternoon, Oct. 4—2:00 P.M.–4:45 P.M.

Electrodeposition (Abstracts 62–66)

(Session in Ohio Room)

Monday morning, Oct. 1—9:30 A.M.–12:00 M.

Electrodeposition—Theoretical Electrochemistry (Abstracts 67–80)

(All sessions in Euclid Ball Room)

Monday afternoon, Oct. 1—2:00 P.M.–5:00 P.M.

Tuesday morning, Oct. 2—9:00 A.M.–12:15 P.M.

Tuesday afternoon, Oct. 2—2:00 P.M.—3:30 P.M.

Electronics—Semiconductors (No abstracts)

(All sessions in Euclid Ball Room)

Wednesday morning, Oct. 3—9:00 A.M.–12:00 M.

Wednesday afternoon, Oct. 3—2:00 P.M.–5:00 P.M.

Thursday morning, Oct. 4—9:00 A.M.–12:00 M.

Thursday afternoon, Oct. 4—2:00 P.M.–5:00 P.M.

Electrothermics and Metallurgy (Abstracts 81–103)

(All sessions in Parlors 1, 2, and 3)

Tuesday morning, Oct. 2—9:00 A.M.–11:00 A.M.

Tuesday afternoon, Oct. 2—2:00 P.M.–4:30 P.M.

Wednesday morning, Oct. 3—9:00 A.M.–11:30 A.M.

Wednesday afternoon, Oct. 3—2:00 P.M.–4:00 P.M.

Theoretical Electrochemistry (Abstracts 104–107)

(Session in Euclid Room)

Tuesday afternoon, Oct. 2—3:40 P.M.–5:20 P.M.

GENERAL INFORMATION

Convention Headquarters will be at the Hotel Statler, Euclid Ave. at East 12th St., Cleveland 1, Ohio.

Rates per day for rooms (with bath) will be: single-room $6.00, 6.50, 7.00, 7.50, 8.00, 8.50, 9.00, 10.50, 11.00, 13.00;

double-bed room $9.50, 10.00, 10.50, 11.50, 12.00, 13.50, 14.00, 16.00; twin-bed room $11.00, 11.50, 12.00, 13.00, 13.50, 14.50, 15.00, 15.50, 16.50, 17.50, 20.00, 22.00, 24.00; suite $24.00, 30.00, 32.00.

Requests for room reservations at the Headquarters Hotel should be made to the Front Office Manager, Hotel Statler, Euclid Ave. at East 12th St., Cleveland 1, Ohio. Mention should be made of The Electrochemical Society.

The office of the Secretary will be in Parlor L on the Club Floor.

All technical sessions will be held on the Ball Room Floor.

Ladies' Headquarters will be in Parlor C, Club Floor. For details, see program under Ladies' Program.

REGISTRATION

The registration desk will be in the Grand Ball Room Mezzanine, Ball Room Floor. On Sunday, September 30, the registration desk will be open from 5:00 P.M. to 8:00 P.M. On Monday, Tuesday, and Wednesday, October 1, 2, and 3, it will be open from 8:00 A.M. to 5:00 P.M.; on Thursday, October 4, from 9:00 A.M. to 12:00 M.

Registration fees are:

Members	$7.00
Ladies	$5.00
Nonmembers	$13.00
Students	Complimentary by prior arrangement

INFORMATION ABOUT CLEVELAND

Members and visitors attending the Fall Meeting of The Electrochemical Society in Cleveland will have an opportunity to observe the burgeoning of one of America's great industrial centers. Already renowned for its key role in the fields of transportation, communication, research, industry, and manufacturing, the planned opening of the St. Lawrence Seaway is sparking another burst of industrial and civic expansion that makes Cleveland an exciting city for strangers to visit and for old friends to renew acquaintance with.

Those arriving by air will be welcomed by the sight of Cleveland's new air terminal, dedicated this year, which is one of the nation's most modern and convenient with every facility for the

traveler. The new Ohio Turnpike, new express highways, and motels will facilitate the arrival of those driving to the convention. On all sides, visitors will see new factories, chemical plants, and research centers.

Electrochemists will have a chance to visit the brand new National Carbon Co. Research Labs. in Parma, Ohio, on the outskirts of Cleveland, and the famous Nela Park Lighting Institute of the General Electric Co. For those in a more academic frame of mind, visits to Western Reserve University and Case Institute of Technology are planned. These trips are scheduled so that there will be no conflict with the technical sessions or other Society functions.

Many attending the meeting will notice the activity for enlarging Cleveland's Port facilities, the arrangements for the Pan-American Games to be held here in 1959, the Urban Redevelopment program where blighted areas are being completely rebuilt, the new Cleveland Engineering Center being built, and many new and enlarged utility services to match the industrial and residential growth of the area.

Of particular interest will be the Acheson Memorial Exhibit which will be displayed at the Main Cleveland Public Library, just a few blocks from the Convention Headquarters. This display of historic material has been selected to illustrate the most significant inventions and works of Dr. Edward Goodrich Acheson on the occasion of the 100th Anniversary of Dr. Acheson's birth.

SPECIAL SYMPOSIA

The Battery Division has scheduled several general symposia, as well as one on the Life of Automotive Batteries, and another on Electrode Polarization.

The Corrosion Division has scheduled symposia on High Temperature Oxidation, Factors Related to Corrosion, Corrosion Kinetics, and the Electrochemistry of Corrosion.

The Electrodeposition and Theoretical Electrochemistry Divisions have both scheduled a general symposia, and jointly are sponsoring symposia on Structure of Metallic Deposits, Kinetics of Electrodeposition, and Diffusion and Convection in Electrodeposition.

The Electronics Division—Semiconductor Group has arranged short "late news" type papers for its four sessions.

The Electrothermics and Metallurgy Division has scheduled two sessions on Acheson Furnaces, Processes, Products, and Related Developments, as well as two on New Chemical Developments in the Extractive Metallurgy of Titanium.

BREAKFASTS, LUNCHEONS, AND DINNERS

Symposia Chairmen Breakfasts

On Monday, Tuesday, Wednesday, and Thursday, October 1, 2, 3, and 4, special breakfasts for all symposia chairmen are being arranged. Information on where breakfasts will be held will be available in the Secretary's office, Parlor L, Club Floor.

Monday, symposia chairmen for Battery and Electrodeposition are requested to attend; **Tuesday,** Battery, Corrosion, Joint Electrodeposition—Theoretical Electrochemistry, Electrothermics and Metallurgy, and Theoretical Electrochemistry; **Wednesday,** Battery, Corrosion, Electronics—Semiconductors, and Electrothermics and Metallurgy; **Thursday,** Corrosion and Electronics—Semiconductors.

Monday Dinner and Open House at National Carbon Research Lab.

On Monday evening, October 1, a buffet dinner will be served at National Carbon's new research laboratories, following which there will be an inspection trip of the laboratories. Ladies, ECS members, and guests are invited. Buses will leave the Hotel Statler at 6:30 P.M. for the laboratory. (Attendance will be limited.)

Tuesday Acheson Medal Banquet

On Tuesday, October 2, a reception and banquet will be held for the Acheson Medalist, Dr. Robert M. Burns. Cocktails will be served from 6:30 to 7:30 P.M. in Private Dining Rooms 1, 2, and 3; dinner at 7:30 in the Grand Ball Room. Dr. Burns will deliver the Acheson Medal Address.

Wednesday Open House

On Wednesday, October 3, at 5:45 P.M., buses will leave the Hotel Statler for Western Reserve University and Case Institute of Technology, both of which are holding open house and are located on adjoining campuses. Members, ladies, and guests may have dinner at Tomlinson Hall, Case Institute of Technology, and after dinner may visit either or both schools.

PLANT TRIPS

Four plant or inspection trips have been planned for the Cleveland Meeting. Participation in these trips must be arranged for at the time of registration at the meeting. Transportation by bus will be arranged.

Monday, October 1, 6:30 P.M.—Dinner and an inspection trip of National Carbon's new research laboratories, located about eight miles from downtown Cleveland, in Parma, Ohio, have been arranged. Transportation from the Hotel Statler to the laboratories will be available by chartered bus leaving at 6:30 P.M. Following dinner served at the laboratories, a tour of this very modern and unusual building is planned. Research facilities available for use in the field of physics, chemistry, and electrochemistry will be open for inspection. Members, guests, and ladies planning to attend are advised to purchase tickets for this trip at the time of registration. The cost per person is $4.00 for dinner and round-trip transportation. (Attendance will be limited.)

Wednesday, October 3, 5:45 P.M.—An open house will be sponsored jointly by the Departments of Chemistry at Western Reserve University and Case Institute of Technology which are located adjacent to each other in the cultural heart of Cleveland. Buses will leave the Hotel Statler for the campuses at 5:45 P.M. Dinner will be served for all attending the open house in the Ball Room of the new Case Student Union (Tomlinson Hall). Following the dinner will be a guided tour in small groups. The Case part of the tour will feature the new Chemistry Building just being completed. On the Western Reserve campus, the tour will include the Electrochemis-

try, Ultrasonics, Cryogenics, and Emission, Absorption, and Mass Spectroscopy Laboratories. Personnel of the Ultrasonics Research Laboratory at Western Reserve University will present a series of demonstrations of the more spectacular effects of ultrasonic waves. Return bus transportation to the Hotel Statler will also be provided. Registrants at the meeting are urged to obtain bus and dinner tickets for the Case-Western Reserve trip early in the week since the number of people who can be accommodated is limited.

Wednesday, October 3, 7:00 P.M.—Buses will leave the Hotel Statler for General Electric's Nela Park Lighting Institute. Members, ladies, and guests are invited to attend. (Nela Park attendance will be limited.) No dinner arrangements are included for this trip. The General Electric Lighting Institute, located at the Lamp Division headquarters in Nela Park, Cleveland, is a contemporary, dynamic, and commercial training facility, the primary purpose of which is education. Its displays and facilities are for training all segments of the lighting industry and its customers in the techniques and values of good lighting practice. The Institute is a part of the marketing organization of the Lamp Division and is staffed by 35 people.

LADIES' PROGRAM

Ladies' Headquarters will be in Parlor C, Club Floor, of the Hotel Statler. All ladies are invited to this Headquarters to obtain information on the program plans and general points of interest in and around Cleveland. A member of the Women's Committee will be in the Ladies' Headquarters on Sunday from 3:00 to 9:00 P.M. to welcome and assist the ladies in every way. The program has been planned to acquaint visitors with many of the interesting and better-known places in the Cleveland area.

Cleveland weather is very unpredictable at this time of the year, so it is rather difficult to advise on what type of clothing to bring. The Cleveland Weather Bureau, however, reports that the maximum afternoon temperature is about 70 degrees and the evening low about 50 degrees.

Monday morning—A get-acquainted period with coffee and rolls will be held in the Ladies' Headquarters, starting at 9:30 A.M.

Monday noon—A luncheon will be held at 12:30 P.M. at Monaco's, for many years a well-known restaurant in downtown Cleveland. Following the luncheon there will be an interesting talk by Florence LeGanke, Food Editor of the Cleveland Press. The remainder of the afternoon will be open for shopping or individual sight seeing.

Monday evening—The ladies are invited to accompany their husbands on the trip to the new National Carbon Research Labs. for a buffet dinner and tour of the bulding.

Tuesday morning and afternoon—Coffee will be served in the Ladies' Headquarters at 9:30 A.M. At 10:45 A.M., meet at the side entrance of the hotel to board a bus to drive along the eastern shore of Lake Erie past the cultural gardens and through some of the loveliest residential sections of the area. Luncheon will be served at Shaker Heights' exclusive Zephyr Room, followed by a drive through the heart of Cleveland's cultural center, and culminated by a visit to the Art Museum. Here, an expert will speak on the subject "Your Home, Traditional or Modern." Return to the hotel will be about 4:30 P.M.

Tuesday evening—The ladies are invited to attend the Acheson Reception and Dinner.

Wednesday morning and afternoon—Coffee will be served in the Ladies' Headquarters at 9:00 A.M. At 10 o'clock, meet at the side entrance of the hotel to journey along the western shore of Lake Erie, through the wooded valley of the Metropolitan Parks, to lunch at the Inn at Oberlin, Ohio. Oberlin is the home of Oberlin College, the first coeducational college in the United States. The return trip will be through the autumn-colored countryside to downtown Cleveland, arriving at the hotel about 3:30 P.M.

Wednesday evening—The ladies are invited to accompany their husbands on either the trip to Case Institute of Technology, Western Reserve University, or General Electric's Nela Park.

Thursday morning—Coffee will be served at 9:00 A.M. in the Ladies' Headquarters. Transportation will be furnished for a sight-seeing boat trip on Lake Erie and through the Cuyahoga River industrial area. The cost of this trip is $1.75 per person. The boat leaves from the dock at 10:00 A.M. and returns by noon.

LUNCHEONS AND BUSINESS MEETINGS OF DIVISIONS

Battery Division will hold a luncheon and business meeting on Tuesday, October 2, at 12:30 P.M. in the Grand Ball Room. C. E. Larson, Vice-President in Charge of Research, National Carbon Co., will speak on "Energy for the Future."

Corrosion Division will hold a luncheon and business meeting on Wednesday, October 3, at 12:30 P.M. in Room 345, 3rd floor.

Electrodeposition Division will hold a luncheon and business meeting on Tuesday, October 2, at 12:30 P.M. in Room 345, 3rd floor.

Electronics Division—Semiconductor Group will hold a luncheon on Thursday, October 4, at 12:30 P.M. in the Pine Room.

BOARD AND COMMITTEE MEETINGS

Sunday, September 30, 10:00 A.M.—Meeting of the Ways and Means Committee in the Tavern Room, Club Floor.

Sunday, September 30, 11:45 A.M.—Meeting of the Finance Committee. Be in Parlor L, the Secretary's office, at 11:45 A.M.

Sunday, September 30, 2:00 P.M.—Meeting of the Board of Directors in the Tavern Room, Club Floor.

Monday, October 1, 5:00 P.M.—Meeting of the Editorial Staff in Parlor B, Club Floor.

Tuesday, October 2, 5:00 P.M.—Meeting of the Membership Committee in Parlor B, Club Floor.

Wednesday, October 3, 5:00 P.M.—Meeting of the Council of Local Sections in Parlor E, Club Floor.

COST OF VARIOUS FUNCTIONS

(other than registration)

Symposia Chairmen Breakfast	$2.00
Division Luncheons	$3.75
Acheson Medal Banquet	
(single)	$6.00
(couple)	$11.00
Trips to National Carbon Research Labs., Western Reserve University, Case Institute of Technology, transportation and dinner	$4.00
Trip to Nela Park Lighting Institute, transportation	$1.00

(Gratuities and taxes included in above prices)

JOURNALS

Copies of the June, July, August, and September issues of the Journal of The Electrochemical Society will be available at the registration desk. The price of a single copy of the JOURNAL is $1.25 to members and $1.75 to nonmembers.

EXTENDED ABSTRACTS

The Battery Division is making available an extended abstract booklet containing 1000-word abstracts of most of the papers presented at the Division's Cleveland symposia. Copies of the booklet will be on sale for $2.00 at the registration desk.

SLIDES AT TECHNICAL SESSIONS

The Board of Directors of the Society does not favor indiscriminate photographing of slides during technical sessions. It is requested that no such photographs be taken. Chairmen of technical sessions should administer this rule.

DISCUSSION

There will be no recordings made of oral discussions. Those contributing to the discussion of a paper and desiring their remarks published will be supplied by the symposium chairman with a printed form on which any discussion may be written. These forms should be given to the Secretary-Treasurer of the Division or to the Managing Editor of

the JOURNAL after the session. The discussion will then be referred to the authors for reply. Written discussion should be submitted within two months following publication of any article in the JOURNAL.

A Discussion Section is published semiannually in the JOURNAL.

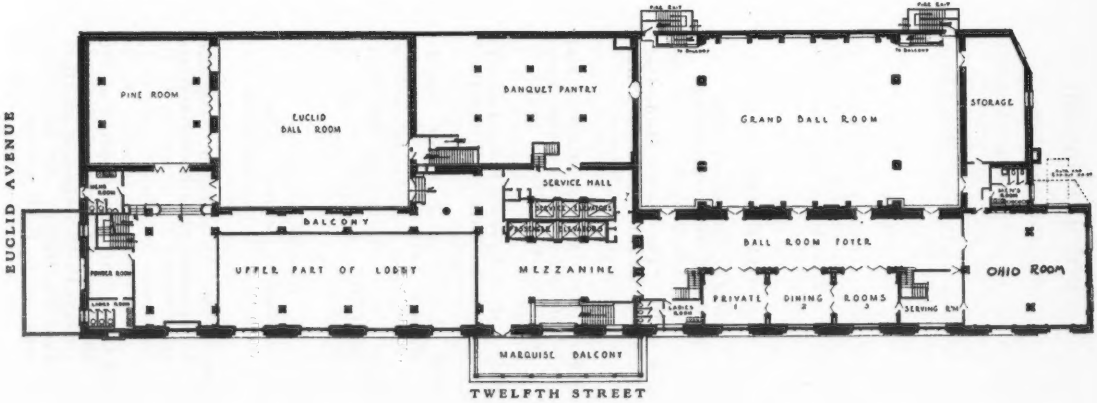
EMPLOYMENT POSTERS

Companies which desire to recruit employees at the Cleveland Meeting will have posters to this effect on a bulletin board near the registration desk.

MEETING ROOM SCHEDULE

Meeting	Monday		Tuesday		Wednesday		Thursday	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
Battery	P	P	P	P	P	P		
Corrosion			O	O	O	O	O	O
Electrodeposition	E							
Electrodeposition—Theoretical Electrochemistry		E	E	E				
Electronics—Semiconductors					E	E	E	E
Electrothermics and Metallurgy			B	B	B	B		
Theoretical Electrochemistry				E				

P = Pine Room.
O = Ohio Room.
E = Euclid Room.
B = Private Dining Rooms 1, 2, and 3.


EUCLID AVENUE
PINE ROOM
EUCLID BALL ROOM
BANQUET PANTRY
SERVICE HALL
GRAND BALL ROOM
STORAGE
BALCONY
UPPER PART OF LOBBY
MEZZANINE
BALL ROOM FOYER
OHIO ROOM
PRIVATE DINING ROOMS
SERVING RM
MARQUISE BALCONY
TWELFTH STREET

Technical Program

Monday, October 1, 1956

9:00 A.M.—Formal Opening of the 110th Convention with Introduction by General Chairman W. H. Stoll and Response by President Hans Thurnauer (Pine Room).

NOTE

Address of author(s) is included with the abstract. In the Index to Authors, the abstract number is used instead of the page number.

BATTERY

Monday, October 1, 1956
with J. C. White presiding
(PINE ROOM)

9:30 A.M.—"The Silver Oxide-Cadmium Alkaline Secondary Battery" by P. L. Howard (Abstract No. 1)

10:00 A.M.—"A Reproducible and Stable Silver-Silver Oxide Electrode" by W. J. Hamer and D. N. Craig (Abstract No. 2)

10:30 A.M.—"Aqueous Potassium Hydroxide as Battery Electrolyte" by T. P. Dirkse (Abstract No. 3)

11:00 A.M.—"Solid Silver Halide Battery Systems" by W. J. van der Grinten (Abstract No. 4)

11:30 A.M.—"The Fused Salt Cell, Mg/$LiNO_3$, KCL/Ag" by C. W. Jennings (Abstract No. 5)

Battery (cont'd)

Monday, October 1, 1956
with E. J. Ritchie presiding
(PINE ROOM)

3:00 P.M.—"*N*-Halogen Organic Compounds as Cathode Materials for Primary Batteries" by C. K. Morehouse and R. Glicksman (Abstract No. 6)

3:30 P.M.—"An Investigation of the Discharge Characteristics of Groups Ib-Vb Oxides in an Alkaline Electrolyte" by R. Glicksman and C. K. Morehouse (Abstract No. 7)

4:00 P.M.—"Some Electrical Properties of Electrode Film Materials, I. Lead Sulfate" by I. H. S. Henderson (Abstract No. 8)

4:30 P.M.—"Supercooling, Preferred Orientation, and Inverse Segregration in Lead-Antimony Alloys" by A. C. Simon and E. L. Jones (Abstract No. 9)

Battery (cont'd)

Tuesday, October 2, 1956

Life of Automotive Batteries
with Eugene Willihnganz presiding

(PINE ROOM)

9:00 A.M.—"Appearance of Battery Components at the End of Life under Laboratory Test" by B. Agruss (Abstract No. 10)

9:25 A.M.—"Correlation of Laboratory Life Tests with Automotive Service Tests of Lead Acid Batteries" by J. F. Schaeffer (Abstract No. 11)

9:50 A.M.—"Effect of Arsenic and Silver in Grid Alloy on Storage Battery Life in Field Tests and Fleet Service" by Howard Stoertz (Abstract No. 12)

10:15 A.M.—"Effect of Normal Car Service on Intermediate and Final Periods of Lead Storage Battery Performance" by Dudley Haskell (Abstract No. 13)

10:40 A.M.—"Effect of Temperature on Cycling Life of Lead Acid Storage Batteries" by J. F. Macholl and A. G. Koch (Abstract No. 14)

11:05 A.M.—"Pulse Maintaining of Automotive Batteries" by J. B. Godshalk (Abstract No. 15)

11:30 A.M.—Open Discussion on Life of Automotive Batteries.

12:30 P.M.—Battery Division Luncheon and Business Meeting in the Grand Ball Room. C. E. Larson, Vice-President in Chargé of Research, National Carbon Co., will speak on "Energy for the Future."

Tuesday, October 2, 1956
with N. C. Cahoon presiding

PINE ROOM

2:00 P.M.—"Positive Post Corrosion in Lead Acid Cells" by O. H. Bauer (Abstract No. 16)

2:30 P.M.—"Self-Discharge Reactions in Lead Acid Batteries" by P. Ruetschi and R. T. Angstadt (Abstract No. 17)

3:00 P.M.—"Self-Discharge of Positively Charged Nickel Oxide Electrodes of Alkaline Storage Batteries" by A. L. Pitman and G. W. Work (Abstract No. 18)

3:30 P.M.—"A Self-Discharge Reaction of Cells with Manganese Dioxide and Metal Electrodes" by W. C. Vosburgh, D. R. Allenson, and Stanley Hills (Abstract No. 19)

4:00 P.M.—"Instrumentation for Use in Storage Battery Studies" G. W. Work and C. P. Wales (Abstract No. 20)

BATTERY—THEORETICAL ELECTROCHEMISTRY

Joint Symposium

Wednesday, October 3, 1956

Electrode Polarization
with U. B. Thomas presiding

(PINE ROOM)

9:00 A.M.—"Corrosion and Polarization" by Norman Hackerman (Abstract No. 21)

9:30 A.M.—"Cathodic Polarization in the Leclanché Cell" by N. C. Cahoon (Abstract No. 22)

10:00 A.M.—"Metal Electrode Polarization" by L. O. Case (Abstract No. 23)

10:30 A.M.—"Polarization Studies of the Lead Electrode" by Eugene Willihnganz (Abstract No. 24)

11:00 A.M.—"Anodic Corrosion and Hydrogen and Oxygen Overvoltage on Lead and Lead-Antimony Alloys" by P. Ruetschi and B. D. Cahan (Abstract No. 25)

Battery—Theoretical Electrochemistry

Joint Symposium (cont'd)

Wednesday, October 3, 1956

Electrode Polarization (cont'd)
with C. W. Tobias presiding

(PINE ROOM)

2:00 P.M.—"Activation Polarization in Battery Systems" by Ernest Yeager (Abstract No. 26)

2:30 P.M.—"Polarization Measurements on High Current Gas Electrodes and Their Conformity with Chemical Test Methods" by K. Kordesch (Abstract No. 27)

3:00 P.M.—"Polarization Characteristics of the Oxygen-Peroxide Couple on Active Carbon Electrodes" by Milton Clark, M. O. Davies, Ernest Yeager, and Frank Hovorka (Abstract No. 28)

3:30 P.M.—"The Overpotential of the Manganese Dioxide Electrode, II. Acid Electrolytes" by S. Yoshizawa and W. C. Vosburgh (Abstract No. 29)

4:00 P.M.—"Role of Ionic Diffusion and Mass Transfer in Kinetics of Electrode Reactions in Batteries" by Morris Eisenberg (Abstract No. 30)

CORROSION

Tuesday, October 2, 1956

High Temperature Oxidation
with J. E. Draley presiding

(OHIO ROOM)

9:00 A.M.—"Oxidation of 50 Weight Per Cent Uranium-Zirconium Alloy" by Sidney Barnartt, R. G. Charles, and E. A. Gulbransen (Abstract No. 31)

9:30 A.M.—"Kinetics of the Oxidation of Chromium" by E. A. Gulbransen and K. F. Andrew (Abstract No. 32)

10:00 A.M.—"High Temperature Scaling of Cobalt-Chromium Alloys" by C. A. Phalnikar, E. B.

Evans, and W. M. Baldwin, Jr.
(Abstract No. 33)

10:45 A.M.—"High Temperature Scaling of Nickel-Manganese Alloys" by E. B. Evans, C. A. Phalnikar, and W. M. Baldwin, Jr.
(Abstract No. 34)

11:15 A.M.—"Oxidation of Iron-Nickel Alloys, III. Kinetics and Mechanism" by R. T. Foley and C. J. Guare (Abstract No. 35)

Corrosion (cont'd)

Tuesday, October 2, 1956

Factors Related to Corrosion
with M. A. Streicher presiding

(OHIO ROOM)

2:00 P.M.—"Hydrogen Diffusion through Steel" by T. J. Butler and R. T. Davis, Jr.
(Abstract No. 36)

2:30 P.M.—"Low-Pressure Solubility and Diffusion of Hydrogen in Zirconium" by M. W. Mallett and W. M. Albrecht (Abstract No. 37)

3:00 P.M.—"Corrosion Characteristics of Uranium. An Electron Diffraction Study" by J. T. Waber and D. D. Whyte
(Abstract No. 38)

3:45 P.M.—"Orientation Factors in Oxide Films on Uranium" by J. T. Waber (Abstract No. 39)

4:15 P.M.—"Variations of Alkaline Anodizing Baths for Magnesium" by W. McNeill and R. Wick
(Abstract No. 40)

4:45 P.M.—"Potential-*p*H Diagram of the Antimony-Water System; Its Applications to Properties of the Metal, Its Corrosion, and Antimony Electrodes" by A. L. Pitman, Marcel Pourbaix, and N. de Zoubov (Abstract No. 40-A)

Corrosion (cont'd)

Wednesday, October 3, 1956

Corrosion Kinetics
with A. H. Roebuck presiding

(OHIO ROOM)

9:00 A.M.—"Effect of Prior Corrosion History on the Corrosion of

Zircaloy-2 in High Temperature Water by D. E. Thomas and S. Kass (Abstract No. 41)

9:30 A.M.—"A Reaction Rate Study of the Corrosion of Low-Hafnium Zirconium in Hydrofluoric Acid Solutions" by Tennyson Smith and G. R. Hill (Abstract No. 42)

10:00 A.M.—"Hydrogen Evolution from dissolving Titanium-Oxygen Alloys in Hydrofluoric Acid and the Constitution of the Ti-O Alloys" by M. E. Straumanis, C. H. Cheng, and A. W. Schlechten (Abstract No. 43)

10:45 A.M.—"Dissolution of Iron in Hydrochloric Acid-Chromic Chloride Solutions" by Robert Skomoroski and C. V. King (Abstract No. 44)

11:15 A.M.—"Kinetics of the Reaction of Steel with Hydrogen Sulfide-Hydrogen Mixtures" by A. Dravnieks and C. H. Samans (Abstract No. 45)

12:30 P.M.—Corrosion Division Luncheon and Business Meeting in Room 345, 3rd floor.

Corrosion

Wednesday, October 3, 1956

Corrosion Kinetics (cont'd)
with A. H. Roebuck presiding

(OHIO ROOM)

2:00 P.M.—"Kinetic Studies on Alkaline Nitrite Formation of Black Oxide Coatings on Mild Steel" by R. M. Hurd and Norman Hackerman (Abstract No. 46)

2:30 P.M.—"Corrosion of Austenitic Stainless Steel in Circulating Uranyl Sulfate Solutions at High Temperatures, I. Experimental Results" by E. G. Bohlmann, J. C. Griess, Jr., and R. S. Greeley (Abstract No. 47)

3:00 P.M.—"Corrosion of Austenitic Stainless Steel in Circulating Uranyl Sulfate Solutions at High Temperatures, II. Mechanism of the Corrosion Process" by J. C. Griess, Jr., and E. G. Bohlmann (Abstract No. 48)

3:35 P.M.—"Corrosion of Austenitic Stainless Steel in Dilute Acid Solutions at High Temperature" by J. C. Griess, Jr., R. S. Greeley, E. G. Bohlmann, and S. R. Buxton (Abstract No. 49)

4:05 P.M.—"An Investigation of the Effect of Chemical Variables on the Corrosion of Copper" by W. D. Robertson, V. F. Nole, W. H. Davenport, and F. P. Talboom, Jr. (Abstract No. 50)

4:35 P.M.—"Corrosion of Single Crystals and Recrystallized Single Crystals of Iron and Steel in Citric Acid" by W. R. Buck, III, and Henry Leidheiser, Jr. (Abstract No. 51)

Corrosion (cont'd)

Thursday, October 4, 1956

Electrochemistry of Corrosion with Milton Stern presiding

(OHIO ROOM)

9:00 A.M.—"Anodic Behavior of Cu in HCl" by R. S. Cooper (Abstract No. 52)

9:30 A.M.—"Stress Potentials for Tension and Torsion Stresses" by W. F. Seyer, O. K. Miniato, and K. Nobe (Abstract No. 53)

10:00 A.M.—"Chemical and Electrochemical Properties of $FeSn_2$" by R. A. Covert and H. H. Uhlig (Abstract No. 54)

10:45 A.M.—"Electrochemical Polarization, I. A Theoretical Analysis of the Shape of Polarization Curves" by Milton Stern and A. L. Geary (Abstract No. 55)

11:15 A.M.—"Oxygen Concentration Cell as a Factor in the Localized Corrosion of Metals" by Wilson Lynes (Abstract No. 56)

Corrosion

Thursday, October 4, 1956

Electrochemistry of Corrosion (cont'd) **with Milton Stern presiding**

2:00 P.M.—"The Mechanisms of Aqueous Corrosion of Aluminum

at 100°C" by K. M. Carlsen (Abstract No. 57)

2:30 P.M.—"Contribution to the Theory of Stress Corrosion in Duralumin Alloys" by W. H. Colner and H. T. Francis (Abstract No. 58)

3:00 P.M.—"Galvanic Corrosion of the Aluminum-Lead Couple in Aqueous Pigment Extracts" by M. J. Pryor, R. J. Hogan, and F. B. Patten (Abstract No. 59)

3:45 P.M.—"Thermogalvanic Potentials and Currents at Aluminum Surfaces in Industrial Water" by E. C. Pitzer (Abstract No. 60)

4:15 P.M.—"Current Efficiency of Magnesium Anodes" by E. H. Phelps (Abstract No. 61)

ELECTRODEPOSITION

Monday, October 1, 1956

General Symposium on Electrodeposition with C. A. Snavely presiding

(OHIO ROOM)

9:30 A.M.—"Electroplating on Aluminum, I. Deposition from Strongly Acid Solutions" by J. T. N. Atkinson (Abstract No. 62)

10:00 A.M.—"Electroplating on Aluminum, II. Deposition of Copper from Oxalate-Pyrophosphate Solutions" by J. T. N. Atkinson (Abstract No. 63)

10:30 A.M.—"Electroplating Baths for Ultrahigh Strength Steel, I. Use of Aliphatic Amino Acids in Cadmium Baths to Reduce Hydrogen Embrittlement" by P. N. Vlannes, S. W. Strauss, and B. F. Brown (Abstract No. 64)

11:00 A.M.—"Electrodeposition of Uranium at the Microgram Level" by C. L. Rulfs, A. K. De, and P. J. Elving (Abstract No. 65)

11:30 A.M.—"Inclusion of Fuchsin in Bright Nickel Deposits" by J. L. Dye and O. J. Klingenmaier (Abstract No. 66)

(Electrodeposition and Theoretical Electrochemistry Division members may be interested in papers on hydrogen in metals and surface treatment of magnesium scheduled for the Corrosion Division session on Tuesday afternoon)

ELECTRODEPOSITION—THEORETICAL ELECTROCHEMISTRY

Joint Symposium

Monday, October 1, 1956

Structure of Metallic Electrodeposits with W. R. Meyer presiding

(EUCLID BALL ROOM)

2:00 P.M.—"Structure of Metallic Electrodeposits" (Keynote Address) by Hellmuth Fischer (Abstract No. 67)

3:00 P.M.—"On the Theory of Electrolytic Crystal Growth" by D. A. Vermilyea (Abstract No. 68)

3:30 P.M.—"Structure of Electrodeposits from Fused Alkalinous Chloride Electrolytes" by R. S. Dean, W. W. Gullett, and F. X. McCawley (Abstract No. 69)

4:00 P.M.—"Comments on Electrodeposition Research on Single-Crystal Substrates" by H. Bandes (Abstract No. 70)

4:30 P.M.—"Studies of the Natural Convection at Vertical Electrodes" by N. Ibl (Abstract No. 71)

Electrodeposition—Theoretical Electrochemistry

Joint Symposium (cont'd)

Tuesday, October 2, 1956

Kinetics of Electrodeposition with Ernest Yeager presiding

(EUCLID BALL ROOM)

9:00 A.M.—"Kinetics of the Deposition of Metals" (Keynote Address) by J. O'M. Bockris (Abstract No. 72)

9:45 A.M.—"High-Speed Polarization Measurements during Electrodeposition" by H. J. Read and C. O. McHugh (Abstract No. 73)

10:15 A.M.—**"Electrochemical Calorimetry"** by Abner Brenner and J. M. Sherfey (Abstract No. 74)

10:45 A.M.—**"Electrodeposition of Nickel from Mixed Solvent Systems"** by Robert Griffis, Ernest Yeager, and Frank Hovorka (Abstract No. 75)

11:15 A.M.—**"A Study of Cathode Potentials in Aqueous Tungstate Solutions"** by D. R. Markwell and M. L. Holt (Abstract No. 76)

11:45 A.M.—**"Design of a New Electrolytic Cell for the Study of Electroplating Phenomena"** by Roger Gilmont and R. F. Walton (Abstract No. 77)

12:30 P.M.—Electrodeposition Division Luncheon and Business Meeting in Room 345, 3rd floor.

Electrodeposition—Theoretical Electrochemistry

Joint Symposium (cont'd)

Tuesday, October 2, 1956

Diffusion and Convection in Electrodeposition with Sidney Barnartt presiding

(EUCLID BALL ROOM)

2:00 P.M.—**"Diffusion and Convection Effects in Electrodeposition"** (Keynote Address) by C. W. Tobias (Abstract No. 78)

2:40 P.M.—**"Limiting Currents at Horizontal Electrodes in Free Convection"** by E. J. Fenech and C. W. Tobias (Abstract No. 79)

3:05 P.M.—**"Throwing Index; A New Graphical Method for Expressing the Results of Throwing-Power Measurements"** by H. F. David and R. V. Jelinek (Abstract No. 80)

ELECTRONICS—SEMICONDUCTORS

Wednesday, October 3, 1956

(EUCLID BALL ROOM)

9:00 A.M.—Papers of the "late news" type. Program and abstracts will be available at the session.

Electronics—Semiconductors (cont'd)

Wednesday, October 3, 1956

(EUCLID BALL ROOM)

2:00 P.M.—Papers of the "late news" type. Program and abstracts will be available at the session.

Electronics—Semiconductors (cont'd)

Thursday, October 4, 1956

(EUCLID BALL ROOM)

9:00 A.M.—Papers of the "late news" type. Program and abstracts will be available at the session.

12:30 P.M.—Electronics Division—Semiconductor Group Luncheon in the Grand Ball Room.

Electronics—Semiconductors (cont'd)

Thursday, October 4, 1956

(EUCLID BALL ROOM)

2:00 P.M.—Papers of the "late news" type. Program and abstracts will be available at the session.

ELECTROTHERMICS AND METALLURGY

Tuesday, October 2, 1956

Acheson Furnaces, Processes, Products, and Related Developments with J. A. Shaw presiding

(PARLORS 1, 2, AND 3)

9:00 A.M.—**"The Acheson Furnace, The Graphitization Process, and Certain Applications of Graphite"** by R. C. Stroup, W. W. Palmquist, and M. Janes (Abstract No. 81)

9:30 A.M.—**"A Survey of Processes in Which Synthetic Graphite Is Used"** by B. L. Bailey and L. H. Juel (Abstract No. 82)

10:00 A.M.—**"Graphite As A Mold Material"** by R. S. Margeson and J. A. Shaw (Abstract No. 83)

10:30 A.M.—**"A Resume of Products Dependent on Synthetic Graphite for Their Manufacture"** by

W. B. Arnold, W. D. Sherrow, and R. E. Lindenmeyr
(Abstract No. 84)

Electrothermics and Metallurgy

Tuesday, October 2, 1956

Acheson Furnaces, Processes, Products, and Related Developments
(cont'd)
with G. M. Butler presiding

(PARLORS 1, 2, AND 3)

2:00 P.M.—"A Review of the Patents on Silicon Carbide Furnacing" by J. C. McMullen
(Abstract No. 85)

2:30 P.M.—"Silicon Carbide Products: Present and Future" by G. M. Butler (Abstract No. 86)

3:00 P.M.—"Electrical Conduction in Silicon Carbide" by G. H. Fetterly
(Abstract No. 87)

3:30 P.M.—"A Rutile Substitute for Ilmenite from the Production of Titanium Metal" by J. H. Brennan and J. G. Farmer
(Abstract No. 88)

3:50 P.M.—"Design and Operation of a Laboratory Smelting Furnace" by R. R. Banks and J. J. Sima
(Abstract No. 89)

4:10 P.M.—"Analysis of Power Requirements and Conditions for Similitude in Electrothermic Furnaces" by Edward Saibel, F. F. Ling, and W. J. Greene
(Abstract No. 90)

Electrothermics and Metallurgy
(cont'd)

Wednesday, October 3, 1956

New Chemical Developments in the Extractive Metallurgy of Titanium
with A. C. Loonam presiding

(PARLORS 1, 2, AND 3)

9:00 A.M.—"The ONR Basic Research Program on the Physico-Chemical Aspects of the Extractive Metallurgy of Titanium" by W. C. Arsem and J. J. Harwood
(Abstract No. 91)

9:20 A.M.—"The Equilibrium between Titanium and Titanium

Chloride in a Sodium Chloride/ Potassium Chloride Melt" by H. H. Kellogg and W. C. Kreye
(Abstract No. 92)

9:40 A.M.—"Equilibria between Titanium Metal and Solutions of Lower Titanium Chlorides in Fused Magnesium Chloride" by K. Komarek and P. Herasymenko
(Abstract No. 93)

10:00 A.M.—"Vapor-Phase Production of Titanium Metal" by Emil Perout (Abstract No. 94)

10:20 A.M.—"The Electrochemistry of Potassium Fluotitanate Melts" by A. J. Kolk, M. E. Sibert, and M. A. Steinberg
(Abstract No. 95)

10:40 A.M.—"Constitution of Alkali Metal Titanium Fluorides in the Molten KCl-LiCl Eutectic Mixture" by C. T. Brown, H. J. Gardner, and G. J. Janz
(Abstract No. 96)

11:00 A.M.—"Vapor Pressure and Thermal Properties of Titanium Tetrabromide" by J. M. Blocher, Jr., N. D. Veigel, and I. E. Campbell
(Abstract No. 97)

Electrothermics and Metallurgy

Wednesday, October 3, 1956

New Chemical Developments in the Extractive Metallurgy of Titanium
(cont'd)
with W. C. Arsem presiding

(PARLORS 1, 2, AND 3)

2:00 P.M.—"Density and Viscosity of Titanium Tetrabromide" by J. M. Blocher, Jr., R. F. Rolsten, and I. E. Campbell
(Abstract No. 98)

2:20 P.M.—"Heat of Formation of Titanium Tribromide by the Mercury Reduction of Titanium Tetrabromide" by E. H. Hall and J. M. Blocher, Jr.
(Abstract No. 99)

2:40 P.M.—"Vapor Pressure of Titanium Tetrafluoride" by E. H. Hall, J. M. Blocher, Jr., and I. E. Campbell (Abstract No. 100)

3:00 P.M.—"Deoxidation of Titanium with Selected Reducing Agents"

by R. B. Liss, E. J. Chapin, and L. Secretan (Abstract No. 101)

3:20 P.M.—"Thermochemistry of the Titanium Tetrahalides" by W. H. Johnson, R. A. Nelson, A. Gilliland, and E. J. Prosen (Abstract No. 102)

3:40 P.M.—"Purification of Titanium Halides and Criteria of Their Purity" by R. B. Johannesen, W. S. Clabaugh, and Raleigh Gilchrist (Abstract No. 103)

THEORETICAL ELECTROCHEMISTRY AND BATTERY

Joint Symposium

Wednesday, October 3, 1956

Electrode Polarization with U. B. Thomas presiding

(PINE ROOM)

9:00 A.M.—*See* Battery—Theoretical Electrochemistry Joint Symposium, page 16.

Theoretical Electrochemistry and Battery

Wednesday, October 3, 1956

Joint Symposium (cont'd)

Electrode Polarization (cont'd) **with C. W. Tobias presiding**

(PINE ROOM)

2:00 P.M.—*See* Battery—Theoretical Electrochemistry, Joint Symposium, page 17.

THEORETICAL ELECTROCHEMISTRY AND ELECTRODEPOSITION

Joint Symposium

Monday, October 1, 1956

Structure of Metallic Electrodeposits with W. R. Meyer presiding

(EUCLID BALL ROOM)

2:00 P.M.—*See* Electrodeposition—Theoretical Electrochemistry Joint Symposium, page 22.

Theoretical Electrochemistry and Electrodeposition

Joint Symposium (cont'd)

Tuesday, October 2, 1956

Kinetics of Electrodeposition with Ernest Yeager presiding

(EUCLID BALL ROOM)

9:00 A.M.—*See* Electrodeposition—Theoretical Electrochemistry Joint Symposium, page 22.

Theoretical Electrochemistry and Electrodeposition

Joint Symposium (cont'd)

Tuesday, October 2, 1956

Diffusion and Convection in Electrodeposition with Sidney Barnartt presiding

(EUCLID BALL ROOM)

2:00 P.M.—*See* Electrodeposition—Theoretical Electrochemistry Joint Symposium, page 23.

THEORETICAL ELECTRO-CHEMISTRY

Tuesday, October 2, 1956 with Frank Hovorka presiding

(EUCLID BALL ROOM)

3:40 P.M.—"The Hydrogen Evolution Reaction on Copper, Gold, Molybdenum, Palladium, Rhodium, and Iron: Mechanism and Measurement. Technique under High Purity Conditions" by N. Pentland, J. O'M. Bockris and E. Sheldon (Abstract No. 104)

4:05 P.M.—"The A-C Response of Electrode Systems to Sinusoidal Pressure Variations, I. Theory" by Ernest Yeager and Frank Hovorka (Abstract No. 105)

4:30 P.M.—"Preparation and Reproducibility of the Thermal Electrolytic Type Silver-Silver Chloride Electrodes' by Harry Taniguchi and G. J. Janz (Abstract No. 106)

4:55 P.M.—"A-C Streaming Potentials" by Irving Galperin, Ernest Yeager, and Frank Hovorka (Abstract No. 107)

ABSTRACTS

BATTERY

Abstract No. 1

The Silver Oxide-Cadmium Alkaline Secondary Battery

P. L. Howard, Yardney Electric Corp., 40–46 Leonard St., New York 13, N. Y.

A battery has been developed which substitutes cadmium for the zinc as negative active material in the silver-zinc secondary battery. By this change in negative the ability to accept CP charge and withstand overcharging has been greatly improved. This couple is more suitable for medium and low rate applications than for high rate use. The discharge voltage is approximately 1.2 v per cell with 30 w hr/lb and 1.5 w hr/in.^{3}. The cycle performance of this battery is rather uniform for several hundred cycles. Two to three thousand shallow cycles (50% capacity) have been obtained from these batteries. General characteristics of this system will be discussed.

Abstract No. 2

A Reproducible and Stable Silver-Silver Oxide Electrode

W. J. Hamer and D. N. Craig, U. S. Dept. of Commerce, National Bureau of Standards, Washington 25, D. C.

A method is described for the preparation of stable and reproducible silver-silver oxide electrodes. In cells of the type: Ag(s), Ag_2O(s) | NaOH, aq. | HgO(s), Hg(l), the electrode potential is stable for 38 days. No evidence was found that Ag, Ag_2O electrodes evolve oxygen, that Ag_2O exists in different forms in aqueous solutions at normal temperatures, that it reverts to a lower oxide, or that it has crystal imperfections. Free energy and entropy changes for the cell reaction at 25°C are −11254 cal and −9.12 e.u. The standard elec-

trode potential of the Ag, Ag_2O electrode is −0.342 v at 25°C.

Abstract No. 3

Aqueous Potassium Hydroxide as Battery Electrolyte

T. P. Dirkse, Calvin College, Grand Rapids 6, Mich.

A study has been made of KOH solutions for use as the electrolyte in alkaline batteries. Solubility relationships of ZnO in KOH were determined at temperatures ranging from −30° to +45°C. A partial phase diagram of aqueous KOH was also obtained. There are indications that the slow precipitation of ZnO from such electrolytes may be hastened by seeding.

Abstract No. 4

Solid Silver Halide Battery Systems*

W. J. van der Grinten, Electronics Lab., General Electric Co., Syracuse, N. Y.

In spite of their low ionic conductivities at room temperature, anhydrous solid-electrolyte battery systems have been given considerable attention during the last few years. Early G. E. research in this area, performed on the systems

$$Ag/AgCl/CuCl_2 + C \quad \text{and}$$

$$Ag/AgBr/CuBr_2 + C$$

will be reviewed. While the discharge mechanism of these systems can be partially explained by assuming the presence of a low-pressure cathode gas, their functioning is not yet fully understood at the present time.

*Work done at the Research Lab., General Electric Co., Schenectady, N. Y.

Abstract No. 5

The Fused Salt Cell

$Mg/LiNO_3$, KCl/Ag

C. W. Jennings, Dept. of Chemistry, N. C. State College, Raleigh, N. C.

The fused salt cell, $Mg/LiNO_3$, KCl/Ag, was studied at temperatures from 300° to 500°C. Cell characteristics varied with the KCl content. With greater than 20% KCl, open-circuit voltages of 1.4–1.6 were obtained. Both silver and magnesium reacted directly with the electrolyte. The extent of reaction of magnesium varied with the KCl content. Substitution of Pt, Ni, or graphite for silver increased the open-circuit voltage. A mechanism is proposed in which silver is involved in the cell reaction.

Abstract No. 6

N-Halogen Organic Compounds as Cathode Materials for Primary Batteries

C. K. Morehouse and R. Glicksman, RCA Labs., Radio Corp. of America, Princeton, N. J.

Half-cell data showing discharge characteristics for various types of *N*-halogen compounds will be presented. Of the various compounds tested, *N*-halogen derivatives of cyclic ureides and amidine derivatives are attractive for use as cathode materials in primary cells. Experimental *N,N'* dichlorodimethylhydantoin-magnesium reserve-type cells have been made and shown to operate at potentials above 2.0 v and give watt-hour capacities per unit of weight and volume comparable to commercially available reserve batteries.

Abstract No. 7

An Investigation of the Discharge Characteristics of Groups Ib-Vb Oxides in an Alkaline Electrolyte

R. Glicksman and C. K. Morehouse, RCA Labs., Radio Corp. of America, Princeton, N. J.

Half-cell discharge data are presented for a number of Groups Ib-Vb oxides discharged in a strongly alkaline solution. Ag_2O, HgO, PbO, Bi_2O_3, and Sb_2O_3 cathodes exhibited flat discharge curves,

while PbO_2 and Tl_2O_3 are reduced stepwise at potentials close to their theoretical value. Anomalous results were obtained for AgO and CuO, their discharge curves showing no break that would indicate a change in reaction mechanism. The relation between the solubility product and operating potential of various silver salts will be discussed.

Abstract No. 8

Some Electrical Properties of Electrode Film Materials,

I. Lead Sulfate

I. H. S. Henderson, National Defense Research Council, Ottawa, Ont., Canada

(No abstract received)

Abstract No. 9

Supercooling, Preferred Orientation, and Inverse Segregation in Lead-Antimony Alloys

A. C. Simon and E. L. Jones, Naval Research Laboratory, Washington 25, D. C.

The previously reported high-Sb concentration in the surface layer of Pb-Sb alloy casting is confirmed and explained by a more exact mechanism. Preferred orientation of this Sb with the [111] direction normal to the surface and the preferred direction of growth parallel to the surface are caused by the strong covalent linkages within the closer pair of (111) planes, and these factors also influence the tensile strength and ductility of the hypereutectic Pb-Sb alloys.

Abstract No. 10

Appearance of Battery Components at the End of Life under Laboratory Test

B. Agruss, Research Labs., National Lead Co., 105 York St., Brooklyn 1, N. Y.

Photographs are shown of the components of batteries at the end of life

under laboratory test conditions. The significance of these photographs is discussed in terms of previous battery history and published results of field surveys of batteries which failed in normal car service.

Abstract No. 11

Correlation of Laboratory Life Tests with Automotive Service Tests of Lead Acid Batteries

J. F. Schaeffer, Globe Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.

An experimental grid alloy has been found which is considerably better than standard antimonial lead when subjected to a laboratory test in which grid corrosion is measured. In field test, however, this alloy corrodes at the same rate as the standard alloy. A review is presented showing that the relative rate of grid corrosion of the two alloys depends on the precise conditions of test.

Abstract No. 12

Effect of Arsenic and Silver in Grid Alloy on Storage Battery Life in Field Tests and Fleet Service

Howard Stoertz, The Electric Storage Battery Co., P. O. Box 5723, Philadelphia 20, Pa.

Addition of As and Ag in small quantities to the grid alloy used in storage batteries produces a marked increase in the corrosion resistance of these grids and leads to greatly improved life in laboratory tests. The combination of As and Ag produces a degree of improvement well beyond the additive effects of the two elements. When used in fleet service, such as police cars and taxicabs, greatly increased life has been obtained.

Abstract No. 13

Effect of Normal Car Service on Intermediate and Final Periods of Lead Storage Battery Performance

Dudley Haskell, W. P. Fuller & Co., South San Francisco, Calif.

A report will be given on the intermediate and final performance records of 66 batteries tested in approximately 150 different cars. Tests were started in 1949 and, with additions since then, continue in progress. Typical causes of failure are discussed, diagnosed, and illustrated with appropriate photographic and photomicrographic examples. Battery performances in 20 hr rate and cold capacity are found to follow a characteristic pattern which might serve as a useful guide in contemplated revisions of the standard cycling life test.

Abstract No. 14

Effect of Temperature on Cycling Life of Lead Acid Storage Batteries

J. F. Macholl and A. G. Koch, Automotive Div., Electric Storage Battery Co., 246 East 131st St., Cleveland 1, Ohio

Results of cycling life tests on lead acid storage batteries are highly influenced by the temperature at which the test is conducted. Temperatures attained in a cell during testing are influenced not only by ambient temperature, but also by the location of that cell with respect to other cells and by the amount of cell area exposed to the surroundings. The behavior of the cells during the SAE life test has been found to correlate with the above, higher cell temperatures favoring longer life. Quantitative relationships are presented.

Abstract No. 15

Pulse Maintaining of Automotive Batteries

J. B. Godshalk, Fox Products Co., 4720 North 18th St., Philadelphia 41, Pa.

The maintenance of automotive batteries while on the shelf by cycles of short time, high rate charges, followed by long dormant periods, is investigated

along with the conventional method of continuous trickle charge. Results from various cycle combinations and continuous trickle rates show that "pulse" maintaining produces better charge maintenance and far less grid corrosion and water consumption than continuous charging. The efficiency of maintenance is shown to approach that of open-circuit storage at low temperatures.

Abstract No. 16

Positive Post Corrosion in Lead Acid Cells

O. H. Bauer, Bowers Battery & Spark Plug Co., Reading, Pa.

Post corrosion is confined to cells used in float service. It becomes manifest by a bulge of the cover around the post. This distortion is caused by a corrosion product underneath the cover. Corrosion is due to an electrolytic action which is produced by areas of different acid concentrations. For the initiation of intensive corrosion, a flaw in the casting is necessary. Fissures resulting from internal shrinkage cavities provide a suitable nucleus.

Abstract No. 17

Self-Discharge Reactions in Lead Acid Batteries

P. Ruetschi and R. T. Angstadt, Research Div., Electric Storage Battery Co., P. O. Box 5723, Philadelphia 20, Pa.

Self-discharge reactions in negative and positive plates of lead acid batteries have been studied under various conditions. The composition of the grid alloy and acid strength have a strong influence on these reactions. Three different reactions are shown to be responsible for the self-discharge of positive plates.

Abstract No. 18

Self-Discharge of Positively Charged Nickel Oxide Electrodes of Alkaline Storage Batteries

A. L. Pitman and G. W. Work, Naval Research Lab., Washington 25, D. C.

Alkaline nickel oxide-iron storage batteries have been charged and put on open circuit. On open circuit the rate of oxygen evolution is proportional to the square root of the water activity in the electrolyte. Therefore, oxygen deposited on the nickel sesquioxide requires interaction with water for its evolution. The potential on decay changes linearly with the quantity of oxygen on the electrode. Adsorption of oxygen on, and desorption from, the nickel sesquioxide is hypothesized.

Abstract No. 19

A Self-Discharge Reaction of Cells with Manganese Dioxide and Metal Electrodes

W. C. Vosburgh, D. R. Allenson, and Stanley Hills, Duke University, Durham, N. C.

Under certain conditions H_2O_2 can be formed by action of metal electrodes on oxygen, and the peroxide can reduce a MnO_2 electrode. Ag electrodes in NH_4Cl electrolyte, Zn in an electrolyte containing a phosphate buffer, and uncleaned Pb in $(NH_4)_2SO_4$ gave pronounced effects. Zn in NH_4Cl, and Ag and clean Pb in $(NH_4)_2SO_4$ gave no effect observable in a one-day period.

Abstract No. 20

Instrumentation for Use in Storage Battery Studies

G. W. Work and C. P. Wales, Electrochemistry Branch, Chemistry Div., Naval Research Lab., Washington 25, D. C.

A storage battery analyzer featuring simplicity and accuracy of control, a wide scope of variables measured, and a complete, continuous record is described and its use is briefly illustrated with actual data. A null-balance servo system controls either the output voltage or current of a rectified d-c power supply

by continuously regulating the a-c input. Individual plate potentials, temperature, gas concentrations, and gas volumes are continuously measured and recorded. Optional equipment permits use in cycling and varied applications.

BATTERY — THEORETICAL ELECTROCHEMISTRY

Abstract No. 21
Corrosion and Polarization

Norman Hackerman, Dept. of Chemistry, University of Texas, Austin 12, Texas

A method for indirect determination of polarization characteristics of anodic reactions involving the electrode metal is described for severe corrosion conditions; possible extension to less corrosive environments is discussed.

Abstract No. 22
Cathodic Polarization in the Leclanché Cell

N. C. Cahoon, National Carbon Research Labs., P.O. Box 6116, Parma, Ohio

Cathodic polarization in the Leclanché cell is analyzed to show the relative importance of a series of factors responsible for its development. The changes in electrolyte *p*H, in the manganese content of the electrolyte, and in the pseudo-equilibrium at the cathode-electrolyte interface during cell discharge are shown to be the most important items responsible for cathode polarization. Use of potential and *p*H measurements on samples of cathode mix is described as a useful tool for studying these phenomena.

Abstract No. 23
Metal Electrode Polarization

L. O. Case, University of Michigan, Ann Arbor, Mich.

Between the terminal states represented by the metal ion in its lattice

and as a hydrated, possibly complex, ion in the bulk of the solution, many stages intervene concerning which thermodynamics furnishes no information. In recent years important knowledge of the mechanism of the over-all process has gained by the systematic study of electrode kinetics. In this branch of kinetics, added complications arise in that electrode reactions are necessarily heterogeneous and that the interfacial potential difference may be a controlling rather than an incidental factor.

Abstract No. 24

Polarization Studies of the Lead Electrode

E. Willihnganz, Gould-National Batteries, Inc., Depew, N. Y.

The electrochemistry of a smooth clean sheet lead in H_2SO_4 was investigated. Short pulses of current 2-0.02 amp cm^2 were applied for a few thousandths of a second and the voltage changes measured on a cathode ray oscillograph. The meaning of the results in terms of cell resistance, double layer capacitance, and the Warburg equivalent circuit is discussed.

Abstract No. 25

Anodic Corrosion and Hydrogen and Oxygen Overvoltage on Lead and Lead-Antimony Alloys

P. Ruetschi and B. D. Cahan, Research Div., Electric Storage Battery Co., P.O. Box 5723, Philadelphia 20, Pa.

The anodic attack of Pb and Pb-Sb alloys has been studied in solutions of H_2SO_4 with constant current methods. Thin layers of PbO_2 were formed and discharged. The PbO_2 discharge step recorded under proper conditions provides a reasonable measure for the depth of attack. Results are discussed in the light of the theory of the metallic bond. Hydrogen and oxygen overvoltage on Pb-Sb alloys in the range from 0 to 11% Sb were measured with the interrupter

technique. Corrosion and overvoltage on single-crystal faces of lead have been studied.

Abstract No. 26

Activation Polarization in Battery Systems

Ernest Yeager, Dept. of Chemistry, Western Reserve University, Cleveland, Ohio

Activation polarization represents departures from thermodynamics as the result of the irreversibility of some chemical or electrochemical step in the electrode reaction. Activation polarization is an important factor in the development of batteries because it often limits the performance of existing batteries and prevents the use of otherwise promising electrode systems. Theoretical factors associated with activation polarization are reviewed relative to battery application. Techniques for the determination of activation polarization are evaluated and procedures for minimizing activation polarization at both anodes and cathodes are described.

Abstract No. 27

Polarization Measurements on High Current Gas Electrodes and Their Conformity with Chemical Test Methods

K. Kordesch, National Carbon Research Labs., P. O. Box 6116, Cleveland 1, Ohio

An improved interrupter circuit using no mechanically moving parts is described and results of measurements on gas electrodes are presented. Processing active carbon material used for heavy duty oxygen electrodes is followed step-by-step and the polarization values at different gas pressures are compared with H_2O_2-decomposition rates and surface measurements. Polarization of Pt-catalyzed carbon electrodes for use with hydrogen has also been studied by the same technique; results are included.

Abstract No. 28

Polarization Characteristics of the Oxygen-Peroxide Couple on Active Carbon Electrodes*

Milton Clark (present address: National Carbon Co., Cleveland, Ohio), M. O. Davies, Ernest Yeager, and Frank Hovorka, Dept. of Chemistry, Western Reserve University, Cleveland, Ohio

Anodic and cathodic polarization associated with the oxygen-peroxide couple have been determined on air-cell carbon electrodes in alkaline solutions with an electronic interrupter. Various types of active carbons have been involved in the preparation of the electrodes. Polarization has been correlated with surface areas and pore size distributions as determined by gas adsorption and gas condensation-vapor pressure methods. Results support the conclusions that the oxygen-peroxide couple is substantially reversible even at apparent current densities through 1 amp/cm^2 and that peroxide and oxygen transport are the cause of polarization.

*Research partially supported by the Office of Naval Research.

Abstract No. 29

Overpotential of the Manganese Dioxide Electrode, II. Acid Electrolytes

S. Yoshizawa and W. C. Vosburgh, Dept. of Chemistry, Duke University, Durham, N. C.

The overpotential of electrodes prepared by electrodeposition on graphite was measured in solutions of H_2SO_4 and manganese (II) sulfate as a function of current density and also of temperature. The relation of overpotential to current density and the shapes of the growth and decay curves can be explained quantitatively on the assumption that the primary reduction product is MnOOH and the electrode potential is dependent on the ratio of MnOOH to MnO_2 on the MnO_2 surface.

Abstract No. 30

Role of Ionic Diffusion and Mass Transfer in Kinetics of Electrode Reactions in Batteries

Morris Eisenberg, Stanford Research Institute, Menlo Park, Calif.

The effect of diffusion and mass transfer on the over-all rate of reactions in batteries is discussed. Following the introduction of the basic concepts of concentration polarization, chemical polarization, and limiting currents, the method of mass transfer analysis is presented and related to electrode processes. A number of specific important cases are discussed. These include: pure diffusion, free convection at vertical plate electrodes, laminar and turbulent flow between parallel electrodes, and a rotating electrode. The importance of the mode of convection is illustrated by limiting current calculations for a given electrode under several different geometrical and hydrodynamic conditions, usually encountered in static and dynamic battery systems.

CORROSION

Abstract No. 31

Oxidation of 50 Weight Per Cent Uranium-Zirconium Alloy

Sidney Barnartt, R. G. Charles, and E. A. Gulbransen, Westinghouse Research Labs., Pittsburgh, Pa.

The reaction of 50% uranium-zirconium with oxygen at 1 atm pressure was studied over the temperature range 200°–500°C. Two forms of the alloy, the stable ϵ-phase and the quenched γ-phase, were reacted to an oxide-scale thickness of 0.1 mm at the higher temperatures. For thick scales on either phase of the alloy, the weight gain increased linearly with time, although in many cases the oxidation curve showed a bend and could be well represented by two straight lines. At 400°C and above, the stable

ϵ-phase reacted considerably faster than the γ-phase. Thick oxide scales were porous and showed uranium enrichment.

Abstract No. 32

Kinetics of the Oxidation of Chromium

E. A. Gulbransen and K. F. Andrew, Westinghouse Research Labs., Pittsburgh, Pa.

The oxidation of high purity chromium is studied between 700° and 1100°C. Below 900°C, conventional oxidation curves are obtained which can be fitted to the parabolic rate law. Above 900°C, the rate of oxidation increases with temperature and time in an unusual manner. At 1050°C, the oxide film is no longer protective and rapid oxidation is observed. The breakdown in the oxidation of chromium is closely related to its high vapor pressure above 900°C.

Abstract No. 33

High Temperature Scaling of Cobalt-Chromium Alloys

C. A. Phalnikar, E. B. Evans, and W. M. Baldwin, Jr., Dept. of Metallurgical Engrg., Case Institute of Technology, Cleveland, Ohio

Scaling rates and scale composition of Co-Cr alloys were determined in the temperature range 900°–1200°C. At any given temperature the scaling rate increased with low Cr additions, then dropped precipitously with further additions reaching a minimum at about 25% Cr. Thereafter the scaling rate again increased approaching the scaling rate of Cr as the upper limit. Above about 25% Cr, the scale consisted exclusively of Cr_2O_3; complex scales were formed. The best scaling resistance was associated with a scale consisting predominantly of Cr_2O_3, not spinel. Schematic isothermal sections of the deduced Co-Cr-O phase diagram were applied as an aid in interpreting the scaling behavior.

Abstract No. 34

High Temperature Scaling of Nickel-Manganese Alloys

E. B. Evans, C. A. Phalnikar, and W. M. Baldwin, Jr., Dept. of Metallurgical Engrg., Case Institute of Technology, Cleveland, Ohio

Ni-Mn alloys scaled in air according to the parabolic rate law. The scaling rate increased with increasing manganese. Both an external scale and subscale were formed. Above a critical concentration of manganese (15% at 600°C to 60% at 1000°C), the external scale consisted exclusively of manganese oxides, and the subscale was MnO. The spinel ($NiO \cdot Mn_2O_3$) found at lower manganese contents was not associated with improved oxidation resistance. Isothermal sections of the Ni-Mn-O phase diagram were applied in interpreting the scaling behavior.

Abstract No. 35

Oxidation of Iron-Nickel Alloys, III. Kinetics and Mechanism

R. T. Foley and C. J. Guare, General Engrg. Lab., General Electric Co., Schenectady, N. Y.

A Chevenard automatic thermobalance and a high temperature electron diffraction unit were used to obtain kinetic and analytical data on the oxidation behavior of the relatively simple Fe-Ni system. The effect of varying oxidation atmosphere and surface preparation was investigated over the range 600°–1000°C for three alloys containing nominally 30, 41, and 78% Ni. Thermodynamic quantities, calculated from the kinetic data, are discussed along with the analytical information to indicate a mechanism for the oxidation.

Abstract No. 36

Hydrogen Diffusion through Steel

T. J. Butler and R. T. Davis, Jr., Applied Research Lab., U. S. Steel Lab., Monroeville, Pa.

A new method has been developed for detecting the hydrogen which diffuses through a steel plate, one side of which is exposed to acid. In this method one side of the plate is in contact with a passivating solution (0.05M sodium dichromate) and on the other side reaction with acid produces hydrogen which diffuses through the steel. With a steel plate 0.010-in. thick the potential of the surface exposed to $Na_2Cr_2O_7$ starts to change in the anodic direction within about 15 sec after the addition of the attacking acid and continues to do so for several hours before becoming constant. The magnitude of the potential change (ca 500 mv) and the rate of change depend on the amount of hydrogen diffusing through the steel plate, the steel composition, and the nature of the attacking acid used in the experiment.

Abstract No. 37

Low-Pressure Solubility and Diffusion of Hydrogen in Zirconium*

M. W. Mallett and W. M. Albrecht, Battelle Memorial Institute, Columbus 1, Ohio

Hydrogen solubilities determined in alpha and beta zirconium and zirconium-oxygen alloys at 700°–1000°C at 0.1–4μ Hg followed Sieverts' law. Solubilities decreased with increasing temperature and increased with oxygen content. Diffusion coefficients and degassing coefficients were determined in the ranges 300°–600°C and 600°–800°C, respectively. Results show that degassing of zirconium is not a pure diffusion phenomenon.

*Work performed under AEC Contract W-7405-eng-92.

Abstract No. 38

Corrosion Characteristics of Uranium. An Electron Diffraction Study

J. T. Waber and D. D. Whyte (present address: Commercial Power Div.,

Westinghouse Electric Corp., Forest Hills, Pittsburgh, Pa.), Los Alamos Scientific Lab., University of California, Los Alamos, N. Mex.

The initial product formed on relatively oxide-free uranium has been shown by electron diffraction to be the alpha or low temperature form of uranium hydride. Such an oxide-free surface has been prepared by polishing the metal within the electron diffraction unit while maintaining a vacuum of 10^{-7} mm Hg. Uranium dioxide lines appear later and grow in intensity. Electron diffraction studies are reported on vacuum annealed metal.

Abstract No. 39

Orientation Factors in Oxide Films on Uranium

J. T. Waber, Los Alamos Scientific Lab., University of California, Los Alamos, N. Mex.

(No abstract received)

Abstract No. 40

Variations of Alkaline Anodizing Baths for Magnesium

W. McNeill and R. Wick, Pitman-Dunn Labs., Frankford Arsenal, Philadelphia, Pa.

The effects of some polyvalent metal anions in magnesium anodizing were compared. Corrosion resistance of coated panels was determined. Hardness and dielectric strength tests were also carried out. Coatings from chromate, stannate, vanadate, tungstate, and manganate baths were compared with those from a bath containing no polyvalent metal anion. Differences in corrosion resistance were noted; vanadate baths produced the best results. Differences in color were noted also.

Abstract No. 40-A

Potential-*p*H Diagram of the Antimony-Water System; Its Applications to Properties of the Metal,

Its Corrosion, and Antimony Electrodes.

A. L. Pitman, Naval Research Lab., Washington 25, D. C.; Marcel Pourbaix, University of Brussels, Brussels, Belgium; and N. de Zoubov, Centre Belge D'Etude de la Corrosion, Brussels, Belgium

Using methods and conventions described previously, together with the available thermodynamics and electrochemical data, equations have been formulated and represented as a potential-pH diagram of the antimony-water system. Another diagram is presented showing zones of corrosion. Free energies of formation of the antimonate ion, $Sb(OH)_6^-$, and the SbO_2^+ ion have been calculated and are given.

Abstract No. 41

Effect of Prior Corrosion History on Corrosion of Zircaloy-2 in High Temperature Water

D. E. Thomas and S. Kass, Atomic Power Div., Westinghouse Electric Corp., P. O. Box 1468, Pittsburgh 30, Pa.

The corrosion of Zircaloy-2 is characterized by a transition from an initial quasi-cubic rate law to a linear rate law which occurs at very long exposure times at temperatures of about 600°F. The linear corrosion rate subsequent to the transition can be determined at low temperatures in a short time by transferring the specimen to the low temperature after having been exposed at higher temperatures for a time sufficient to reach the linear portion of the weight gain vs. time curve. Such experiments are described together with transient effects which persist for a time after a specimen has been transferred from one temperature to another.

Abstract No. 42

A Reaction Rate Study of the Corrosion of Low-Hafnium Zirconium in Hydrofluoric Acid Solutions

Tennyson Smith and G. R. Hill, Fuel Technology Dept., University of Utah, Salt Lake City, Utah

The rate of dissolution of zirconium in HF solutions has been studied using a radioactive tracer, Zr^{95}. By an appropriately designed system, continuous records of the rates could be made. The rate has been found to be dependent on the HF (free acid) activity alone, at constant temperature. A number of possible mechanisms for the slow step are suggested, the most likely one being the diffusion of HF to the zirconium surface. Reaction products are demonstrated to be mostly ZrF_3^+ ion in the solution, and H_2 in the gas phase. The activation energy for the slow step is 3.3 kcal/mole.

Abstract No. 43

Hydrogen Evolution from Dissolving Titanium-Oxygen Alloys in Hydrofluoric Acid and the Constitution of the Ti-O Alloys

M. E. Straumanis, C. H. Cheng (present address: 530 East Green St., Champaign, Ill.), and A. W. Schlechten, Dept. of Metallurgy, University of Missouri School of Mines and Metallurgy, Rolla, Mo.

Ti-O alloys dissolve in HF according to the reaction $TiO_x + 3HF \rightarrow TiF_3 + xH_2O + 0.5\ (3 - 2x)\ H_2$, with a maximum for $x = 1.5$, which means that Ti_2O_3 dissolves without hydrogen evolution. Higher titanium oxides do not dissolve in HF. The determination of the end point of the above reaction was affected by a secondary, but very slow, reaction $TiF_3 + HF \rightarrow TiF_4 + 0.5\ H_2$. Nevertheless, experimental results agreed within $\pm 2\%$ for the first reaction for Ti containing oxygen up to 33 at.%. Ti-O alloys do not represent titanium oxygen solid solutions but solid solu-

tions of titanium oxides and titanium metal.

Abstract No. 44

Dissolution of Iron in Hydrochloric Acid-Chromic Chloride Solutions

Robert Skomoroski and C. V. King, Dept. of Chemistry, New York University, New York 3, N. Y.

The dissolution rate of rotating iron cylinders was studied in 4M HCl containing purple and green forms of $CrCl_3$ up to 0.2M. Only small changes in the rate in acid alone were found, with no reduction of chromic ion. Although the standard potentials predict that reduction is possible, the actual potential of iron in acid solutions is more noble. Cathodic polarization gave sufficiently negative potentials, but only resulted in cathodic protection to the iron, with no reduction of chromic ion. Further, it was shown that metallic iron catalyzes the oxidation of chromous ion by hydrogen ion.

Abstract No. 45

Kinetics of the Reaction of Steel with Hydrogen Sulfide-Hydrogen Mixtures

A. Dravnieks and C. H. Samans, Standard Oil Co. (Indiana), Whiting, Ind.

(No abstract received)

Abstract No. 46

Kinetic Studies on Alkaline Nitrite Formation of Black Oxide Coatings on Mild Steel

R. M. Hurd and Norman Hackerman, Defense Research Lab. and Dept. of Chemistry, University of Texas, Austin, Texas

Formation of black-oxide (magnetite) coatings on mild steel in hot concentrated solutions of NaOH and $NaNO_2$ was studied over the temperature range 130°–150°C. The following mechanism is proposed for the over-all reaction:

$$Fe \xrightarrow{OH^-} Fe^{++} \xrightarrow{NO_2^-} FeO_2^-$$

$$\xrightarrow{Fe^{++}} Fe(FeO_2)_2$$

Of the total iron dissolved, only about 30% was converted to black oxide on the surface. Rates for oxide-free surfaces, as $dC_{Fe^{++}}/dt$, were obtained from the initial slopes of rate curves of total iron dissolved vs. time. Plots of the initial rates vs. $1/T$ were linear, and the slopes gave an "activation energy" of 39,000 cal/mole. As the oxide coating built up, the rates dropped to a fraction of the initial rate, and were apparently controlled by diffusion of the reactants through the coat.

Abstract No. 47

Corrosion of Austenitic Stainless Steel in Circulating Uranyl Sulfate Solutions at High Temperatures, I. Experimental Results

E. G. Bohlmann, J. C. Griess, Jr., and R. S. Greeley, Oak Ridge National Lab., Oak Ridge, Tenn.

The successful development of aqueous homogeneous reactors has required a knowledge of the corrosion resistance of a number of metals and alloys to aqueous fuel solutions at high temperature. The present paper summarizes corrosion results that have been obtained in an extensive testing program in which several austenitic stainless steels have been exposed to circulating uranyl sulfate solutions in the absence of high-level radiation. Effects of uranyl sulfate concentration, temperature, flow rate, and additives, such as copper sulfate and oxygen, on the corrosion of stainless steel are discussed.

Abstract No. 48

Corrosion of Austenitic Stainless Steel in Circulating Uranyl Sulfate Solutions at High Temperature, II. Mechanism of the Corrosion Process

J. C. Griess, Jr., and E. G. Bohlmann, Oak Ridge National Lab., Oak Ridge, Tenn.

A reasonable mechanism for the corrosion of stainless steel in high temperature uranyl sulfate solutions has been formulated. It has been shown that, if the corrosion of stainless steel is to be minimized, a protective oxide coating must form on the surface of the steel. From a consideration of the chemistry of uranyl sulfate solutions and the hydrolytic behavior of the corrosion products, it is possible to explain the effect of flow rate, uranium concentration, and temperature on the formation of the oxide coating, and, consequently, on the corrosion of stainless steel. An examination of the chemical reactions involved in the corrosion process shows that it is necessary to maintain an oxidizing agent such as oxygen in the system and that, if oxygen is used, its consumption can be related to the quantity of steel corroded.

Abstract No. 49

Corrosion of Austenitic Stainless Steel in Dilute Acid Solutions at High Temperature

J. C. Griess, Jr., R. S. Greeley, E. G. Bohlmann, and S. R. Buxton, Oak Ridge National Lab., Oak Ridge, Tenn.

The corrosion of several austenitic stainless steels in dilute sulfuric, nitric chromic, and phosphoric acid solutions has been studied under dynamic conditions at temperatures as high as 300°C. The severity of corrosion depended on the particular acid, its concentration, flow rate, temperature, and the presence of additives. The chemistry of the process is discussed and results are compared with those obtained in uranyl sulfate solutions.

Abstract No. 50

An Investigation of the Effect of Chemical Variables on the Corrosion of Copper

W. D. Robertson (Yale University, New Haven, Conn.; consultant), V. F. Nole, W. H. Davenport, and F. P. Talboom, Jr., Research and Development Dept., Chase Brass and Copper Co., Waterbury, Conn.

The corrosion rate of Cu has been measured as a function of *p*H in the range 1.6–6, anion type and concentration, oxygen and CO_2 concentration, and temperature in a system maintained at constant composition throughout a given test. Data show that the rate is proportional to hydrogen ion concentration and to oxygen concentration in the range of concentrations corresponding to air saturation; it is independent of the growth of films in time. Results indicate that the rate, *C.R.*, may be expressed in terms of the difference in a saturation concentration, C_E, and the concentration maintained in the system at any time, C: $C.R. = a + b(C_E - C)$. The temperature dependence of the rate, at constant oxygen concentration, for both chloride and sulfate solutions, is: rate $= Ae^{-9000/RT}$.

Abstract No. 51

Corrosion of Single Crystals and Recrystallized Single Crystals of Iron and Steel in Citric Acid

W. R. Buck, III, and Henry Leidheiser, Jr., Virginia Institute for Scientific Research, Richmond, Va.

Armco iron and L-steel (321) faces corroded approximately two times faster than (100) faces at 20° and 100°C. Fe(100) was cathodic to Fe(321) at 20°C. Recrystallization of single crystals to polycrystalline material resulted in an increased corrosion rate. In the presence of 40–45 ppm of Sn(II), corrosion rates of single crystals were reduced and no difference between the (100) and (321) faces was observed.

Abstract No. 52

Anodic Behavior of Cu in HCl

R. S. Cooper, Dept. of Physics, University of Illinois, Urbana, Ill.

(No abstract received)

Abstract No. 53

Stress Potentials for Tension and Torsion Stresses

W. F. Seyer, O. K. Miniato, and K. Nobe, Dept. of Engineering, University of California, Los Angeles 24, Calif.

Measurements of stress potentials annealed and cold worked copper wires were made with steady current flow in NaCl solutions. For the former, below the elastic limit, emf varied as $(\text{stress})^2$ for tension and torsion, that for cold worked varied directly. For annealed wire $T\Delta S \rightarrow 0$, not for the other. Here cold work is associated with entropy because of increased disorder of crystal lattice. For the same stress, emf for annealed was twice the cold worked.

Abstract No. 54

Chemical and Electrochemical Properties of $FeSn_2$

R. A. Covert and H. H. Uhlig, Corrosion Lab., Dept. of Metallurgy, Massachusetts Institute of Technology, Cambridge 39, Mass.

Corrosion properties of the $FeSn_2$ alloy layer existing between iron and tinplate are investigated. Corrosion potentials, cathodic polarization characteristics, and corrosion rates of Fe, Sn, and $FeSn_2$ in deaerated 4% NaCl + HCl (*p*H 2.0) and deaerated 0.1M citric acid solutions are reported. The possible effects of $FeSn_2$ on the corrosion behavior of tinplate are discussed on the basis of these measurements.

Abstract No. 55

Electrochemical Polarization, I. A Theoretical Analysis of the Shape of Polarization Curves

Milton Stern and A. L. Geary, Metals Research Labs., Electro Metallurgical Co., P. O. Box 580, Niagara Falls, N. Y.

The shape of polarization curves and the causes of deviation from "true" Tafel behavior are described. For a non-corroding electrode, deviations at low overvoltages are due to the reverse reaction of the oxidation-reduction system, at high overvoltages to concentration and/or resistance polarization. Representation of the local polarization diagram of a corroding electrode by considering the forward and reverse reactions of both oxidation-reduction systems forming the corrosion couple provides a clearer understanding of the factors affecting the corrosion rate and shape of polarization curves. A new approach to the study of corroding metals is provided by describing a region of linear dependence of potential on applied current. An equation relates the slope of this linear region to the corrosion rate and Tafel slopes.

Abstract No. 56

Oxygen Concentration Cell as a Factor in the Localized Corrosion of Metals

Wilson Lynes, Research Dept., Revere Copper and Brass Inc., Rome, N. Y.

The oxygen concentration cell has been reviewed in relation to metallic corrosion, with emphasis on current determining factors. Its discovery and early history are outlined, and environmental conditions favorable to its development are classified and discussed. Theories of the mechanism of the cell are presented.

Abstract No. 57

The Mechanisms of Aqueous Corrosion of Aluminum at 100°C

K. M. Carlsen, % Joint Establishment for Nuclear Energy Research, Post Box 175, Lillestrom, Norway

Various alloys of aluminum, as well as super purity aluminum material, have been tested in aqueous solutions at 100°C. Samples have been polarized cathodically and anodically to study the effect of cathodic and anodic reactions, respectively, on the corrosion behavior. Results are interpreted as showing that the alkalinity produced at the cathodes facilitates film breakdown in these places. Consequently, alloys containing cathodic constituents are attached where these constituents are situated, while polycrystalline super purity material is attacked in the grain boundaries. Finally, the influence of cold work, bulk *p*H, and inhibitors is discussed in some detail.

Abstract No. 58

Contribution to the Theory of Stress Corrosion in Duralumin Alloys

W. H. Colner and H. T. Francis, Armour Research Foundation of Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

Stress cracking of duralumin alloys was found to be greatly influenced by exposed area of the specimen (small areas showed long time-to-failure). Experiments with grain boundary-grain center couples showed that neither potentials nor couple current were influenced sufficiently by stress to account for the acceleration of failure by stress. At constant applied anodic current, however, stress was found to direct the attack perpendicular to applied stress. A theory is proposed in which final stages of failure result from plastic flow of grain boundary zones, preventing film maintenance, and resulting in direct and rapid metal attack.

Abstract No. 59

Galvanic Corrosion of the Aluminum-Lead Couple in Aqueous Pigment Extracts

M. J. Pryor, R. J. Hogan, and F. B. Patten, Kaiser Aluminum & Chemical Corp., Spokane 69, Wash.

Aqueous extracts from metallic lead and litharge accelerate the corrosion of high purity aluminum on account of the deposition of metallic lead from solution. Galvanic corrosion in these extracts is enhanced by high *p*H and high lead content of the extracts. Extracts from red lead and basic lead carbonate do not accelerate the corrosion of aluminum. Due to their low *p*H values and lower lead contents those extracts do not deposit metallic lead on aluminum. Lead linoleate is an excellent corrosion inhibitor for aluminum and, in addition, inhibits the galvanic corrosion of aluminum coupled to lead.

Abstract No. 60

Thermogalvanic Potentials and Currents at Aluminum Surfaces in Industrial Water

Edgar C. Pitzer, (present address: General Electric Co., Appliance Park, Louisville, Ky.), Hanford Atomic Products Operation, General Electric Co., Richland, Wash.

Potentials and galvanic currents at 2S aluminum surfaces in Columbia river water were studied between room temperature and 100°. The potential of the aluminum changed by approximately 0.6 v over this interval, becoming more anodic with increase in temperature. Similar but somewhat smaller changes in potential were noted in buffer solutions. By coupling identical aluminum samples, one at 100° and the other at room temperature, a maximum current density of 40 $\mu a/cm^2$ was maintained.

Abstract No. 61

Current Efficiency of Magnesium Anodes

E. H. Phelps, Applied Research Lab., U. S. Steel Corp., Monroeville, Pa.

Electrode potential measurements, hydrogen evolution measurements, weight loss determinations, and the rotogenerative method of detecting corrosion currents were used to study the corrosion of Mg in NaCl solutions. Results obtained were explained by the view that the major anode reaction of Mg consists of Mg entering the solution as monovalent Mg ions, a portion of which react with the solution to form divalent Mg ions and hydrogen gas. This view indicates why the current efficiency of Mg anodes is approximately 50% as a maximum when based on the Mg corroding directly to form divalent Mg ions.

ELECTRODEPOSITION

Abstract No. 62

Electroplating on Aluminum, I. Deposition from Strongly Acid Solutions

J. T. N. Atkinson, Naval Research Establishment, Dartmouth, N. S.

Development of a method for plating copper on aluminum from strongly acid solutions is recorded. The aluminum or aluminum alloy needs to be prepared for plating by a degreasing operation only, since the plating bath itself has sufficient reactivity toward the aluminum oxide film to allow plating on aluminum with substantial adhesion. Good results were obtainable with a surprisingly wide range of acid copper solutions.

Abstract No. 63

Electroplating on Aluminum, II. Deposition of Copper from Oxalate-Pyrophosphate Solutions

J. T. N. Atkinson, Naval Research Establishment, Dartmouth, N. S.

The best plating variants discussed in the previous paper are considered in more detail. A moderately acid copper

solution containing oxalates, pyrophosphates, ammonia, and triethylamine has been found to be most effective for plating copper on aluminum. Rack and barrel plated work can be controlled to give adhesion in excess of the ultimate properties of tin-lead solder, and promising initial results have been obtained for copper plating aluminum wire in a continuous wire plating device.

Abstract No. 64

Electroplating Baths for Ultrahigh Strength Steels, I. Use of Aliphatic Amino Acids in Cadmium Baths to Reduce Hydrogen Embrittlement.

P. N. Vlannes, S. W. Strauss, and B. F. Brown, Physical Metallurgy Branch, Metallurgy Div., Naval Research Lab., Washington 25, D. C.

Noncyanide aqueous baths containing aliphatic amino acids were studied for their characteristics in plating cadmium on ultrahigh strength steel. Polarographic data, plating evaluation, and embrittlement characteristics (as determined by the delayed fracture, static fatigue test in tension using notched bars) are presented. Delayed fracture tests indicate that plating from such baths occasions markedly lower hydrogen embrittlement than plating from the accepted cyanide bath.

Abstract No. 65

Electrodeposition of Uranium at the Microgram Level

C. L. Rulfs, A. K. De and P. J. Elving, Dept. of Chemistry and Engineering Research Institute, University of Michigan, Ann Arbor, Mich.

The recovery of microgram and submicrogram quantities of uranium by electroplating has been studied, using as a tracer radioactive uranium-233 with and without the presence of microgram quantities of natural uranium as carrier. Optimum results were obtained in an ammonium oxalate medium with electrolysis at 80°–85° being first performed

in acidic solution and then in alkaline solution. A small platinum disk, which fitted into a flow counter, was used as cathode and a platinum spiral served as anode. With 20 μg of uranium carrier present and a volume of 25 ml, an average recovery, based on alpha counting, of 94.3 $\pm$ 3.0% was obtained for amounts of uranium-233 ranging from 0.03 to 0.13 μg.

Abstract No. 66

Inclusion of Fuchsin in Bright Nickel Deposits

J. L. Dye and O. J. Klingenmaier, Dept. of Chemistry, Michigan State University, East Lansing, Mich.

Fuchsin, a brightener used in nickel plating, was recovered from nickel deposits by dissolving the deposits in HCl. The amount of fuchsin recovered per gram of nickel was roughly linear in fuchsin concentration and decreased with increasing current density. Some pertinent properties of fuchsin were studied. The amount of fuchsin included and its brightening effect are correlated with a model which assumes preferential adsorption at grain corners and edges.

ELECTRODEPOSITION—THEORETICAL ELECTROCHEMISTRY

Abstract No. 67

Structure of Metallic Electrodeposits

Hellmuth Fischer, Siemens & Halske Aktiengesellschaft, Werkstoff-Hauptlaboratorium, Karlsruhe i.B., Rheinbrückenstrasse 50, Germany

As-deposited structures are to be distinguished from poststructures. Characteristic of electrocrystallization is the wide scale of crystal imperfections, lattice dislocations caused by sorption or desorption of codeposited hydrogen, growth layers as most important base forms, spiral steps (with high Burgers

vector), electrolyte components occluded at grain and subgrain boundaries, rhythmic lamellar bands, micropores, and outgrowths. Aggregates of layers and crystals classified according to typical growth forms are discussed.

Abstract No. 68

On the Theory of Electrolytic Crystal Growth

D A. Vermilyea, Research Lab., General Electric Co., Schenectady, N. Y.

The electrodeposition of metals is considered in the light of the screw dislocation theory of crystal growth, which should be valid for electrodeposition on most metals. Equations are developed to give the current as a function of voltage for various conditions involving different combinations of the surface diffusion distance, the distance between kinks in the steps of the screw dislocations, and the current density relative to the exchange current density.

Abstract No. 69

Structure of Electrodeposits from Fused Alkalinous Chloride Electrolytes

R. S. Dean, W. W. Gullett, and F. X. McCawley, Chicago Development Corp., Riverdale, Md.

The structure and mechanism of formation of deposits formed by the electrolysis of fused systems of alkalinous metal, chlorine, and metals such as Ti, Zr, and Cr has been studied over wide ranges of electrolyte composition and conditions of electrolysis. The study has given particular attention to Ti. Conditions for making relatively thick, adherent, nonporous plates are given, and, more importantly from the standpoint of electrorefining conditions, for producing bundles of coarse filamentary particles having high bulk density yet freely draining the fused salt and adhering sufficiently to the cathode for practical operations.

Abstract No. 70

Comments on Electrodeposition Research on Single-Crystal Substrates

H. Bandes, Sylvania Electric Products Inc., Woburn, Mass.

A summary of some recent work in areas cognate to electrodeposition will be presented to support the contention that research on the structure of electrodeposits should be done on single-crystal substrates. Starting with Clark, Pish, and Weeg's x-ray structure investigations of about 1942, the argument will be advanced through a discussion of Gwathmey's etch and oxidation pattern work of the last several years and Müller's field emission microscopy studies. This discussion will then be tied into some comments on the energetics of electrode reactions and the basis of the contention will then be self-evident.

Abstract No. 71

Studies of the Natural Convection at Vertical Electrodes

N. Ibl, Laboratory for Physical Chemistry and Electrochemistry, Eidg. Technische Hochschule, Zurich, Switzerland

(No abstract received)

Abstract No. 72

Kinetics of the Deposition of Metals

J. O'M. Bockris, University of Pennsylvania, Philadelphia, Pa.

Methods of evaluating the mechanism of the deposition of metals from a knowledge of its kinetics are reviewed briefly. Potential energy surfaces for metal deposition reactions are examined and shown to allow the elimination of several hypothetical kinetic paths. Determination of the parameters of metal deposition and other fast reactions is examined; it is shown that previous attempts at such determinations may

have been in error owing to the effects of dielectric loss in the solvent molecules in the double layer.

Abstract No. 73

High-Speed Polarization Measurements during Electrodeposition

H. J. Read and C. O. McHugh, Dept. of Metallurgy, Pennsylvania State University, University Park, Pa.

Through use of a suitable exploring electrode, a vacuum-tube voltmeter, a d-c amplifier, and a fast-writing recording oscillograph, it has been possible to measure polarization effects during short plating times at high current density and to observe phenomena which would not be detectable by the customary manual methods of polarization measurement. The usefulness of the technique is illustrated with data obtained from studies in tin plating solutions.

Abstract No. 74

Electrochemical Calorimetry

Abner Brenner and J. M. Sherfey, Div. of Chemistry, National Bureau of Standards, U. S. Department of Commerce, Washington 25, D. C.

The energetics of electrochemical reactions have been studied by means of calorimetry. Data obtained lead directly to the value of the enthalpy change which accompanies a reaction and indirectly to the thermodynamic constants of complex equilibria in solution. This method has been applied to a study of the cyanide complexes of monovalent copper. Theoretical considerations indicate the possibility of applying the technique to the study of polarization.

Abstract No. 75

Electrodeposition of Nickel from Mixed Solvent Systems

Robert Griffis, Ernest Yeager, and Frank Hovorka, Dept. of Chemistry, West-

ern Reserve University, Cleveland 6, Ohio

Polarization and structural data were obtained for the deposition of nickel from pure and mixed solvent systems of methyl alcohol and water. Polarization measurements were made with an electronic interrupter. An all-glass cell was used in order to control such variables as concentration gradients, electrochemical purity, current distribution, temperature, and isolation from the atmosphere. Energies of activation in both systems as well as the Tafel slopes support the theory of slow discharge of the ion as being the rate-determining step. A face-centered cubic lattice structure was found for all deposits examined.

Abstract No. 76

A Study of Cathode Potentials in Aqueous Tungstate Solutions

D. R. Markwell and M. L. Holt, Chemistry Dept., University of Wisconsin, Madison, Wis.

Cathode potential measurements with a specially designed cell are used to obtain information about the cathode processes involved in the electrodeposition of tungsten alloys from aqueous solutions. Changes in observed cathode potential values resulting from varying the cathode current density and the electrolysis solution are noted. A hypothesis to explain some of the peculiarities of the cathodic reduction of aqueous tungstate solutions is proposed.

Abstract No. 77

Design of a New Electrolytic Cell for the Study of Electroplating Phenomena

Roger Gilmont, Manostat Corp., New York, N. Y., Polytechnic Institute of Brooklyn, Brooklyn, N. Y., and R. F. Walton, Tube Dept., RCA Labs., Radio Corp. of America, Harrison, N. J.

By means of the theory of the electropotential, the geometrical shape of a new

electroplating cell was deduced in which the current density along the cathode is linear and can be calculated directly from the total current and voltage of the cell. The new cell consists of a container with two straight sides intersecting at 45° and two curved sides consisting of rectangular hyperbolic cylinders orthogonal to each other, and each in turn orthogonal to one of the straight sides. One of the straight sides and its opposite curved surface are insulators, the other straight side is the cathode, while the remaining curved surface is the anode. The new cell may not only be used for current density studies, but also to determine the total polarization directly from simple measurements on the cell combined with the electrical conductivity of the solution.

Abstract No. 78

Diffusion and Convection Effects in Electrodeposition

C. W. Tobias, Dept. of Chemistry and Chemical Engineering, University of California, Berkeley 4, Calif.

Progress made in recent years in the quantitative interpretation of mass transport effects in electrodeposition is reviewed. At all practical current densities the interfacial composition of electrolyte at the cathode is substantially different from that in the bulk. Effect of stirring, flow of electrolyte, or movement of cathode on the interfacial composition can be estimated with an accuracy depending on the complexity of the system under investigation. The effect of local and average mass transport rates in the electrolyte on the character of deposits and on the macro- and micro- "throwing power" can often be predicted.

Abstract No. 79

Limiting Currents at Horizontal Electrodes in Free Convection

E. J. Fenech and C. W. Tobias, Dept. of Chemistry and Chemical Engrg.,

University of California, Berkeley 4, Calif.

Limiting currents for the deposition of copper from acid solutions of copper sulfate have been measured over a range of concentrations, viscosities, and with variations of cell geometry, in all cases in the absence of external stirring. For horizontal cathodes facing upward the data obtained could be correlated in a dimensionless form. On the basis of experimental data and theoretical considerations the mechanism of ionic mass transport at horizontal electrodes has been found to differ from that established for vertical electrodes.

Abstract No. 80

Throwing Index; A New Graphical Method for Expressing the Results of Throwing-Power Measurements

H. F. David and R. V. Jelinek, Dept. of Chemical and Metallurgical Engrg., Syracuse University, Syracuse 10, N. Y.

A new direct method is proposed for expressing results of throwing-power measurements made on plating solutions in a conventional rectangular throwing-power box with plane parallel electrodes. The metal distribution ratio (M) is plotted vs. the linear ratio (P) on arithmetic coordinates. The reciprocal of the slope of this plot is called "throwing index" and represents a direct measure of bath throwing power. Experimental data on several solutions are presented and advantages of this method are discussed.

ELECTROTHERMICS AND METALLURGY

Abstract No. 81

The Acheson Furnace, the Graphitization Process, and Certain Applications of Graphite

R. C. Stroup, W. W. Palmquist, and M. Janes, National Carbon Co., Ni-

agara Falls, N. Y., and Cleveland, Ohio

The early history and continuing evolution of the Acheson furnace for the thermal conversion of carbon to artificial graphite are described. Data are presented on the changes in such properties as electrical and thermal conductivity, coefficient of thermal expansion, x-ray line shape, etc., with furnace temperature; the mechanism of the thermal recrystallization from carbon to graphite is discussed. Industrial utilization of the unique physical characteristics of graphite is illustrated through references to its use as a corrosion resistant material of construction and as a high temperature refractory material. Graphite, and especially impervious graphite, possesses particular advantages for chemical processing equipment items. Uses of graphite involving exposure to high temperatures are covered.

Abstract No. 82

A Survey of Processes in Which Synthetic Graphite Is Used

B. L. Bailey and L. H. Juel, Electrode Div., Great Lakes Carbon Corp., P.O. Box 637, Niagara Falls, N. Y.

A brief description will be given of commercial processes in which artificial graphite plays an important part. Processes covered include operations involving arc furnaces, resistance furnaces, induction furnaces, electrolytic and electromotive cells, metal casting, high temperature powder metallurgy, nuclear reactions, corrosive materials or atmospheres, sliding friction, commutation, and cathodic protection.

Abstract No. 83

Graphite as a Mold Material

R. S. Margeson and J. A. Shaw, International Graphite & Electrode Div., Speer Carbon Co., Niagara Falls, N. Y.

Graphite as produced in the Acheson

type of furnace possesses properties which make it an ideal material with which to construct molds for casting a wide variety of metals, alloys, and other castable materials as well as hot pressing many powders requiring extremely high temperatures. Special applications involving coatings and impregnants of the graphite are also covered.

Abstract No. 84

A Resume of Products Dependent on Synthetic Graphite for Their Manufacture

W. B. Arnold, W. D. Sherrow, and R. E Lindenmeyr, Electrode Div., Great Lakes Carbon Corp., P.O. Box 637, Niagara Falls, N. Y.

A brief discussion will be given of the scope and importance of commercial products which depend on the unique properties of synthetic graphite for their manufacture. The commercial fields covered include ferrous and nonferrous are furnace products, products of various electrolytic operations, and products where graphite is used as a component.

Abstract No. 85

A Review of Patents on Silicon Carbide Furnacing

J. C. McMullen, Engineering Research Branch, The Carborundum Co., Niagara Falls, N. Y.

A review of the progress in the manufacture of silicon carbide as reflected by the patent literature dating from Acheson's original patent issued in 1893 is given. A complete list of patents reviewed is presented while those considered most pertinent are discussed. Possible future trends are noted.

Abstract No. 86

Silicon Carbide Products: Present and Future

G. M. Butler, Engineering Research Branch, The Carborundum Co., Niagara Falls, N. Y.

The evolution of a whole family of products made with silicon carbide is outlined to show the importance of Acheson's discovery. Known properties of silicon carbide are used to forecast new areas for exploitation of this unique compound.

Abstract No. 87

Electrical Conduction in Silicon Carbide

G. H. Fetterley, Norton Co., Niagara Falls, Ont., Canada

Commercial silicon carbide is a semiconductor that can be prepared as predominantly *n*- or *p*-type at will. Body conductivity is linear, and determines the behavior of SiC heating elements, which are usually made from *n*-type. The interfacial conductivity is much lower, nonlinear, and is exploited in lightning arresters, which are made from *p*-type. While the electrical behavior of this material is still poorly understood in detail, the broad outlines are summarized in terms of semiconductor theory.

Abstract No. 88

A Rutile Substitute from Ilmenite for the Production of Titanium Metal

J. H. Brennan and J. G. Farmer, Electro Metallurgical Co., Niagara Falls, N. Y.

Ilmenite is processed by a partial reduction process in resistor furnaces to yield a titanium suboxide carbide product and iron. Iron may be readily separated magnetically. The titanium suboxide carbide product is preferable to rutile for the production of titanium tetrachloride.

Abstract No. 89

Design and Operation of a Laboratory Smelting Furnace

R. R. Banks and J. J. Sima, Metallurgical Process Div., Air Reduction Co., Inc., Murray Hill, N. J.

A 120-kw open, in-line smelting furnace has been built to permit the evaluation of raw materials for the manufacture of calcium carbide and the study of electric smelting phenomena in general. Use of this furnace has permitted satisfactory testing of charge materials with appreciable savings in material and time over those required for plant-scale evaluation. Work is in progress on the refinement of predictions of the performance of large furnaces by analysis of laboratory furnace data.

Abstract No. 90

Analysis of Power Requirements and Conditions for Similitude in Electrothermic Furnaces

Edward Saibel, Dept. of Mathematics, Carnegie Institute of Technology, Pittsburgh, Pa.; and F. F. Ling and W. J. Greene, Air Reduction Co., Inc., Murray Hill, N. J.

Theoretical power requirements of electrothermic furnaces are discussed. Losses due to conduction, convection, and radiation are considered. Methods of scaling the model to prototype are considered in relation to the relative importance of the type of loss which, in turn, depends on furnace design and mode of operation. Application to the manufacture of calcium carbide is treated as an example.

Abstract No. 91

The ONR Basic Research Program on the Physico-Chemical Aspects of the Extractive Metallurgy of Titanium

W. C. Arsem and J. J. Harwood, Office of Naval Research, Washington, D. C.

(No abstract received)

Abstract No. 92

Equilibrium between Titanium and Titanium Chloride in a Sodium Chloride/Potassium Chloride Melt

H. H. Kellogg, Columbia University,

New York, N. Y.; and W. C. Kreye, Brooklyn Polytechnic Institute, Brooklyn, N. Y.

(No abstract received)

Abstract No. 93

Equilibria between Titanium Metal and Solutions of Lower Titanium Chlorides in Fused Magnesium Chloride

K. Komarek and P. Herasymenko, Research Div., New York University, New York, N. Y.

Measurements of the total pressure of titanium chlorides over mixtures of $TiCl_2$ and fused $MgCl_2$ in the presence of metallic titanium indicate limited solubility of $TiCl_2$ in liquid $MgCl_2$ in the range from 720° to 800°C. Thermal analyses have shown that the system $TiCl_x$-$MgCl_2$ has a peritectic point at about 1 mole % $TiCl_x$. The peritectic temperature is 720°C. The system was investigated up to about 50 wt % $TiCl_x$ where complete solubility is attained at 930°C. The ratio of $TiCl_2$ to $TiCl_3$ in the salt is practically constant in the whole investigated range, and is equal to 7.7. No $TiCl_4$ was detected in the salt.

Abstract No. 94

Vapor Phase Production of Titanium Metal

Emil Perout, Clevite Research Center, Div. of Clevite Corp., Cleveland, Ohio

$TiCl_4$ and magnesium metal were reacted in the vapor stage to produce titanium metal. Two reactors were constructed during the period of the investigation. Both were similar in operation to a flow reactor. Investigations showed that a successful temperature, using molybdenum containers, was approximately 800°C. Pressure of about 100 μ Hg was needed. Titanium metal was recovered with efficiencies up to 55%.

Abstract No. 95

Electrochemistry of Potassium

Fluotitanate Melts

A. J. Kolk, M. E. Sibert, and M. A. Steinberg, Horizons, Inc., Cleveland, Ohio

(No abstract received)

Abstract No. 96

Constitution of Alkali Metal Titanium Fluorides in the Molten KCl-LiCl Eutectic Mixture

C. T. Brown, H. J. Gardner, and G. J. Janz, Dept. of Chemistry, Rensselaer Polytechnic Institute, Troy, N. Y.

The conductance and cryoscopic behavior of the alkali metal titanium fluorides in the molten KCl-LiCl eutectic mixture have been investigated to gain information on the ionic nature of the melts. A large decrease in conductance is observed on the addition of alkali metal titanium fluorides, indicating a decrease in electrovalency of the melt as a whole. Data are reported for the conductance and cryoscopic behavior for these compounds and more simple alkali halide salts in the KCl-LiCl eutectic melt. The structure and constitution of these melts are considered in the light of these results.

Abstract No. 97

Vapor Pressure and Thermal Properties of Titanium Tetrabromide

J. M. Blocher, Jr., N. D. Veigel, and I. E. Campbell, Battelle Memorial Institute, Columbus, Ohio; and R. F. Rolsten, E. I. du Pont de Nemours & Co., Wilmington, Del.

The vapor pressure of liquid titanium tetrabromide was measured over the temperature range from the melting point (38.2°C) to the boiling point (231.6°C) with the following results:

$$TiBr_4(l) = TiBr_4(g)$$

$$\log p_{atm} = 16.6190 - 3.8117 \log T - 3188.18/T$$

$$\Delta H_{504.8} = 10.16 \text{ kcal}$$
$$\Delta H_{298.2} = 13.02 \text{ kcal}$$
$$\Delta S_{298.2} = 27.48 \text{ e.u.}$$

In order to treat the data thermodynamically, the following properties were measured or calculated: heat capacity, heat of fusion, and melting point of the solid, heat capacity of the liquid, and the heat capacity and standard entropy of the vapor.

Abstract No. 98

Density and Viscosity of Titanium Tetrabromide

J. M. Blocher, Jr., and I. E. Campbell, Battelle Memorial Institute, Columbus, Ohio; and R. F. Rolsten, E. I. du Pont de Nemours & Co., Wilmington, Del.

Measurements were made of the density and viscosity of liquid titanium tetrabromide between 40° and 130°C leading to the equations

$$d = 2.953 - 0.00225(t - 40)$$

and

$$\eta = \frac{3.746}{1 + 0.0246t - 0.0000243t^2}$$

where d is in g/cc, η is in centipoises, and t is in °C. Measurements of the vapor density at the boiling point indicate that titanium tetrabromide is monomolecular.

Abstract No. 99

Heat of Formation of Titanium Tribromide by the Mercury Reduction of Titanium Tetrabromide

E. H. Hall and J. M. Blocher, Jr., Battelle Memorial Institute, Columbus, Ohio

Equilibrium data on the mercury re-

duction of titanium tetrabromide were combined with the heat of formation of titanium tetrabromide and mercurous bromide to obtain, for the heat of formation of titanium tribromide,

$$\tfrac{3}{2}Br_2(l) + Ti(\alpha) = TiBr_3(s)$$
$$\Delta H_{298.2} = -130.8 \pm 1.1 \text{ kcal}$$

Complications in the system:

$$TiBr(g) + Hg(l) = \tfrac{1}{2}Hg_2Br_2(s) + TiBr_3(s)$$

are discussed.

Abstract No. 100
Vapor Pressure of Titanium Tetrafluoride

E. H. Hall, J. M. Blocher, Jr., and I. E. Campbell, Battelle Memorial Institute, Columbus 1, Ohio

Measurements of the vapor pressure of titanium tetrafluoride were made by three independent methods over the temperature range 435°–555°K with the result for

$$TiF_4(s) = TiF_4(g)$$

$$\log p_{atm} = 33.787 - 6507.9/T - 8.05 \log T$$

With an estimated value of $\Delta C/_p = -16$, the data lead to: $\Delta H_{298.2} = 25.00$ kcal; $\Delta S_{298.2} = 47.43$ e.u.

Abstract No. 101
Deoxidation of Titanium with Selected Reducing Agents

R. B. Liss, E. J. Chapin, and L. Secretan, Nonferrous Alloys Branch, Metallurgy Div., Naval Research Lab., Washington 25, D. C.

Since relatively small amounts of oxygen contamination produce a marked reduction in the ductility of titanium, a means for deoxidation of contaminated metal is of major industrial importance. Pure thorium and gadolinium each have been found to deoxidize molten titanium containing 1 wt % oxygen. An 8.4 wt % addition of thorium removes about 82 wt

% of the oxygen from solution by forming ThO_2 while an addition of 7.5 wt % gadolinium removes about 90 wt % of the oxygen from solution by forming gadolinium oxide. Recovery of ductility as a result of deoxidation is evidenced by hardness measurements and mechanical properties.

Abstract No. 102

Thermochemistry of the Titanium Tetrahalides

W. H. Johnson, R. A. Nelson (present address: Alcohol Tax Unit, Treasury Dept., Washington, D. C.), A. Gilliland, and E. J. Prosen, Thermochemistry Section, Div. of Chemistry, National Bureau of Standards, Washington 25, D. C.

Direct calorimetric measurements have been made on the heat of formation of $TiCl_4(g)$ and $TiBr_4(c)$ from Ti(c) and gaseous halogen. Reduction of the data to standard conditions gives the following results: $Ti(c) + 2Cl_2(g) = TiCl_4(liq)$; $\Delta H°_{(298.16°K)} = -192.1 \pm 0.7$ kcal/mole; $Ti(c) + 2Br_2(liq) = TiBr_4(c)$; $\Delta H°_{(298.16°K)} = -147.40 \pm 1.10$ kcal/mole.

Heats of hydrolysis of $TiCl_4(liq)$, $TiBr_4(c)$, and $TiI_4(c)$ in acid solutions have also been measured. Details of the apparatus and experimental techniques will be given.

Abstract No. 103

Purification of Titanium Halides and Criteria of Their Purity

R. B. Johannesen, W. S. Clabaugh, and Raleigh Gilchrist, Chemical Div., National Bureau of Standards. Washington 25, D. C.

Procedures are described for preparing titanium halides in a state of high purity, as well as for determining their purity by cryoscopic, spectrochemical, and infrared absorption measurements. Detailed account is given of the preparation of titanium tetrachloride, the starting material for preparing the other halides, with a purity of 99.9990 mole %, and of tita-

nium tetrabromide with a purity of 99.998 mole %. Description is also given of the preparation of titanium trichloride and of titanium tetraiodide.

THEORETICAL ELECTROCHEMISTRY

Abstract No. 104

Hydrogen Evolution Reaction on Copper, Gold, Molybdenum, Palladium, Rhodium and Iron: Mechanism and Measurement Technique Under High Purity Conditions.

N. Pentland, J. O'M. Bockris, and E. Sheldon, University of Pennsylvania, Philadelphia 4, Pa.

During the past five years, a number of experimental and theoretical techniques have been devised whereby the attack on the mechanism of electrode reactions need no longer be prosecuted by qualitative inference but by the evaluation of diagnostic criteria which allow unambiguous decisions between mechanisms to be made. The determination of the most important relevant parameters used for the evaluation of diagnostic criteria for the hydrogen evolution reaction have been applied to Cu, Au, Mo, Pd, Rh, and Fe cathodes. The necessary details of the technique of measuring currents of electrodes under ultrahigh purity conditions for electrode reactions which are easily vitiated by the presence of trace impurities are also given here for the first time.

Abstract No. 105

A-C Response of Electrode Systems to Sinusoidal Pressure Variations, I. Theory*

Ernest Yeager and Frank Hovorka, Dept. of Chemistry, Western Reserve University, Cleveland 6, Ohio

Sinusoidal pressure variations at sufficiently low frequencies produce alternating components in the potential of a reversible electrode in accord with thermodynamics. With increasing frequency,

instantaneous equilibrium is no longer maintained at the electrode and the effect decreases. Equations have been derived which relate the a-c response of the electrode to frequency in terms of the reaction constants of the rate-determining steps and the double-layer capacity. The dependence of the a-c response on frequency should provide information concerning the kinetics of the electrode processes. With the proper electrode system, it should be possible also to calculate the partial molal volume of a single type of ion with a minimum of controversial assumptions.

*Research partially supported by the Office of Naval Research.

Abstract No. 106

Preparation and Reproducibility of the Thermal Electrolytic Type Silver-Silver Chloride Electrodes

Harry Taniguchi and G. J. Janz, Dept. of Chemistry, Rensselaer Polytechnic Institute, Troy, N. Y.

A procedure in detail is described for the preparation of the thermal-electrolytic silver-silver chloride for precision use. A reproducibility of the electrodes by this procedure of only ±0.1 mv can be expected unless the freshly prepared electrodes are evaluated relative to equilibrated silver-silver chloride electrodes selected as reference standards. With care, reference standards corresponding to an electrode in the ground energy state, and of constant potential (±0.005 mv) for periods of several months can be attained. It is suggested that the difference in the values of the standard potential of this electrode may be attributed in part to the limited reproducibility of these electrodes. The importance of the factors of porosity, amount of silver chloride, and color, relative to the attainment of stable electrodes that equilibrate rapidly are considered in this communication.

Abstract No. 107

A-C Streaming Potentials*

Irving Galperin, Ernest Yeager, and Frank Hovorka, Ultrasonics Research Lab., Western Reserve University, Cleveland, Ohio

Apparatus has been developed for the measurement of the streaming potentials associated with bi-directional sinusoidal flow of electrolytic solutions through porous media. Results of a-c measurements are compared with those obtained with unidirectional flow in terms of the following porous materials: surgical cotton, nylon, Pyrex, and ion-exchange resins of both the cation and anion type. The primary advantage of the a-c method is the relatively small amount of solution required for the measurements.

*Research partially supported by the Office of Naval Research.

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SPRING MEETING

at the

STATLER HOTEL

Washington, D. C.

May 12, 13, 14, 15, and 16, 1957

Sessions probably will be scheduled on

Electric Insulation

Electronics (including Luminescence, Semiconductors, Oxide Cathodes, Instrumentation, and possibly Screen Applications)

Electrothermics and Metallurgy

Industrial Electrolytics

Theoretical Electrochemistry (including a special symposium on electrolytes)

Abstracts for the Spring Meeting (*not exceeding 75 words in length*) must reach the Secretary's Office, 216 West 102nd Street, New York 25, N. Y. *not later than January 2, 1957* in order to be included in the program.

Indicate on abstract for which Division's symposium the paper is to be scheduled.

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